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E L E M E N T A R Y

ANATOMY AND PHYSIOLOGY,

FOR COLLEGES, ACADEMIES,
AND OTHER SCHOOLS.

BY

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AND

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P R E F A C E .

THIS work is offered to the public in the hope that it has some desirable features as a text-book, not found in any of the able elementary works on Anatomy and Physiology now extant. One is, the introduction of more of microscopic anatomy than is usual. Another is, a large addition on Comparative Anatomy, which is now become a science of great importance. A third is, the Religious Applications of these sciences; which, although all will acknowledge to be eminently appropriate, we have found in no elementary treatise.

We make no pretensions to distinguished attainments or reputation in these sciences, as a reason for writing this book. But both of us have for a great number of years been in the habit of hearing recitations and giving lectures upon them in the College and the Academy, and we ought to know what sort of a text-book is needed. But we dare not boast that we have come up to our ideal. We have tried to give a condensed yet clear exhibition of the leading principles and facts, which are detailed in such works as Carpenter's Human Physiology, his Comparative Physiology, Hassall's Microscopic Anatomy, Griffith and Henfrey's Micrographic Dictionary, Peaslee's Histology, Todd and Bowman's Physiological Anatomy, Wilson's and Gray's Anatomy, Draper's, Dunglinson's, and Dalton's Physiologies, Van Der Hoeven's Zoology, and the works of Cuvier, Owen, Agassiz, Wyman, Leidy, and Wagner on Comparative Anatomy.

Through the liberality of the publishers we are able to present unusually full illustrations of subjects, which could otherwise be only imperfectly comprehended by the learner.

Many of the drawings contain more minute details of the parts represented than are described in the text. The instructor can require these to be recited or not, as he pleases, according to the age and ability of the pupil. So as to the parts on Comparative Anatomy, as they are distinctly separated from the rest, they can, if desired, be passed over in recitation.

At the earnest solicitation of my son, my name stands first on the title-page. But justice requires me to state that most of the body of the work has been prepared by him. I have supposed it most appropriate that it should be so, since he has, and I have not, passed regularly through the medical school. Yet perhaps the public may have some confidence in my judgment as a teacher for more than forty years, in shaping the materials so as to be best adapted for purposes of instruction. But aware, in some measure, of our deficiencies and imperfections, neither of us, in sending forth the work, feels it to be beyond criticism and improvement. In a field so wide, where so many are pushing their investigations, and the highest authorities so frequently change their views, we do not expect to avoid all mistakes; but in our successive editions, we shall correct all errors which we find, and try to incorporate the new discoveries.

EDWARD HITCHCOCK.

AMHERST COLLEGE July, 1860.

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PRELIMINARY

DEFINITIONS AND PRINCIPLES.

1. ALL the objects in the material world are divided into Organic and Inorganic.

2. Cells, Membranes, and Fibers.—In organic bodies, the matter composing them is arranged in the form of cells, membranes, and fibers, variously combined. In inorganic bodies, though the particles are often arranged with mathematical precision in particular modes, cells, membranes, and fibers are not formed.

3. Life.—The principle of life is always associated with organic, but never with inorganic bodies.

4. Examples of Organic and Inorganic Objects.—Organic bodies embrace Animals and Plants; every thing else in the material world is inorganic, as, air, water, minerals, rocks, and soils.

5. Man the Head of the Animal Kingdom.—“Man is the end toward which all the animal kingdom has tended from the first appearance of the Palæozoic fishes.”—AGASSIZ and GOULD.

6. Anatomy and Physiology.—Anatomy is the science that

QUESTIONS. 1. Give the two kingdoms of the material world. 2. What is the arrangement of matter in organic and inorganic bodies? 3. With which is life associated? 4. State some examples of organic and inorganic bodies. 5. Why is man placed at the head of the animal kingdom? 6. Define Anatomy.

describes the different organs of animals. Physiology describes their functions, or uses. If the organs of man alone be described, the science is called Human Anatomy and Physiology. If the description embrace the lower animals, it is called Comparative Anatomy and Physiology.

7. Another definition of Anatomy, is the science of Organization; and of Physiology, the science of Life.

8. Animal and Vegetable Anatomy and Physiology.—There are also such sciences as Vegetable Anatomy and Physiology. Indeed, there is a strong analogy between the organs of plants and animals, and their uses. Nor is it easy always to draw the line between plants and animals, where they approach the nearest to each other.

9. Intimate Connection of Anatomy and Physiology.—Few writers confine themselves to the structure of animals, when treating of their anatomy, but treat also of the function of their organs; and the same thing is still more generally true of writers on physiology. We do not separate these sciences in this treatise.

10. Fifteen Chemical Elements in the Human Body.—Of the sixty-five chemical elements or simple bodies known to exist, only fifteen have been found as normal constituents of the human body. The following is the list:—

1. Oxygen,	6. Phosphorus,	11. Chlorine,
2. Hydrogen,	7. Calcium,	12. Fluorine,
3. Carbon,	8. Magnesium,	13. Silicon,
4. Nitrogen,	9. Sodium,	14. Iron,
5. Sulphur,	10. Potassium,	15. Manganese.

11. Carbon, Hydrogen, Oxygen, and Nitrogen.—The first three of the above elements are found in all the solids and fluids of the body, without exception. The first four occur in all the

What is Physiology? When is the term comparative applied? 7. Give a more concise definition of Anatomy and Physiology. 8. Describe animal and vegetable Physiology. 9. Speak of the close relationship between Anatomy and Physiology. State the whole number of chemical Elements. 10. State those which are found in the human body. 11. Where are the first three found? Nitrogen also?

solid parts, and in all the fluids except fat. They form the chief and most important ingredients in animals and plants.

12. Sulphur and Phosphorus, Magnesium, Sodium, Potassium, Chlorine, Fluorine, Calcium, Silicon, Iron, Manganese.—With scarcely an exception, these elements exist in the body as compounds; that is, two or more of them are combined, as in water, in oxyds, and in various salts. Sulphur and phosphorus exist in albumen and fibrine, as well as in the brain, about $\frac{1}{10}$ th of its weight being phosphorus. Bones are more than half made up of Phosphate of Lime, and they contain a small per cent. of Phosphate of Magnesia. Sodium, in the form of a chlorid (common salt), is found in every solid and fluid of the body. Potassium occurs as a chlorid in the muscles, and as an oxyd in salts. Chlorine forms chlorohydric acid by combining with hydrogen in the gastric juice. Fluorine exists in the bones in a minute quantity, combined with calcium. Silicon is found in small quantities in hair, wool, and feathers, as silica. Iron forms about the 2000th part of the blood, and it exists also in the muscles, hair, and milk. Manganese, in small quantities, has been detected in bone, and perhaps in the hair.

13. Copper, Lead, and Arsenic.—Copper, lead, and arsenic have been detected in minute quantity in human flesh. But it is not probable that they are normal constituents.

14. Inferences.—From these facts we learn that our food and drink should contain the fifteen ingredients above described. Milk and eggs are the only articles that do contain them all; and hence, the importance of variety in diet. And the fact that we are obliged to use ten mineral ingredients in our food, shows the absurdity of a prevalent prejudice that no mineral should ever be taken as a medicine.

15. Immediate Principles.—As they exist in the body, the

12. State in what organs Sulphur and Phosphorus are found. What is one of the principal ingredients of bones? Where is Chlorine found? Fluorine? Silicon? In what parts of the body is Iron found? 13. What is to be said of Copper, Lead and Arsenic? 14. What should our food contain? Are mineral ingredients always poisonous? 15. Define Immediate Principles.

fifteen elements above described form a large number of compounds, called Immediate Principles, or Organic Radicals. They exist naturally, and can be separated anatomically, that is, mechanically, from one another; but the divisions can be carried no further without chemical decomposition. A few elementary substances found in the system, as, oxygen, hydrogen, and nitrogen, are sometimes called Immediate Principles.

16. Immediate Principles Chemically Grouped.—We are certain that eighty-four of these principles have been found in the human system. If we group them according to their chemical characters, they will fall into the following divisions. Half of them are the result of the waste or metamorphosis of the substance of the body; the other half exist independently of any such change.

1. *Gaseous, and not saline*: Oxygen, Hydrogen, Nitrogen, Carbonic Acid, and Water.

2. *Salts*: Chlorids (2), Fluoride of Calcium, Hydrochlorate of Ammonia, Carbonates (4), Bicarbonate of Soda, Sulphates (3), Phosphates (7), Lactates (3), Oxalate of Lime, Urates (5), Hippurates (3), Inosate of Potassa, Pneumate of Soda, Taurochlorate of Soda, Hyocholate of Soda, Glycocholate of Soda, Oleate of Soda, Margarate of Soda, Stearate of Soda, Caproate of Potassa, Soda, &c.

3. *Acids*: Lactic, Uric, Hippuric, Pneumic, Lithofallic, Margaric, and Stearic.

4. *Neutral Nitrogenous Compounds*: Creatine, Urea, Cystine, and Creatinine.

5. *Neutral Non-Nitrogenous Compounds*: Sugar from the Liver, and Sugar of Milk.

6. *Fatty and Saponaceous Compounds*: Cholesterine, Oleic Acid, Stearic Acid, Oleine, Stearine, &c. (13.)

7. *Coagulable Principles*: Fibrine, Albumen, Caseine, Globuline, Musculine, Osteine, Keratine, Hematine, &c. (18.)

16. State the number of these principles that have been already found. What are one-half of them derived from? Give the first group, or the gaseous ones. State the Salts. The Acids. The 4th, 5th, 6th and 7th classes.

17. *Immediate Principles Physiologically Grouped.*—If we group the preceding substances according to their physiological relations, we might, with Dr. Carpenter, bring them all into four divisions.

1. *Histogenetic Substances*, or such as are converted into animal substances, and are nitrogenous.

2. *Calorific Substances*, mainly intended to produce heat, and are non-nitrogenous, as, sugar and oils.

3. *The components of the living animal substance.*

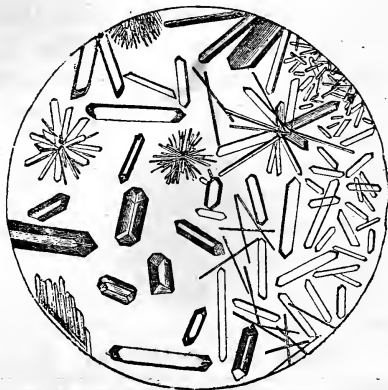
4. *Excrementitious Substances*, formed within the body, and thrown out of it.

18. *Other Probable Principles.*—Quite a number of other substances have been detected in the human system, which some regard as immediate principles. But it is safer to wait till further examination has removed doubt.

19. Several of the above principles are capable of crystallization, and are sometimes found in that state in the body. Figs. 1 and 2 show two examples of these crystals, the first of Hippuric acid, and the other of Creatine.

20. To go into minute details respecting the immediate principles above described, would occupy too much space in a work like the present. But a few statements respecting the most import-

FIG. 1.



17. What are the Groups of these substances when physiologically grouped? Who is the authority for this? Define the Histogenetic and the Calorific group. What are excrementitious substances? Are there any other principles in the body?

FIG. 2.



An adult consumes in a year about eight hundred pounds of oxygen. An inhabitant of a mountainous region 18,000 feet above the sea (in Potosi) consumes, however, only two thirds as much as one upon the sea-shore.

22. Hydrogen and Nitrogen.—Hydrogen is found in a free state in the stomach and some parts of the intestines, and nitrogen in the lungs, blood, and intestines.

23. Carbonic Acid.—Carbonic acid is found in the lungs, the alimentary canal, the blood, and urine.

24. Water; Cubical Size of the Body.—Water enters into the composition of every fluid, and every solid in the body. The bulk of the body, upon an average, is equal to a cube of a little more than sixteen inches on a side; and the amount of water equals a cube a little more than fourteen inches on a side, or nearly three fourths of the body. Every part, except bone, enamel, teeth, tendon, dry cuticle, and elastic tissue, is more than half water.

21. How much Oxygen by weight is found in the body? What bulk of oxygen is found in the venous and what in the arterial blood? How much does an adult consume by respiration and otherwise in a year?—What effect does elevation above the sea have upon the amount consumed? 22. State how Hydrogen and Nitrogen are found. 23. Carbonic acid also. 24. How important a constituent is water? Give the size of the body if reduced to a cube. If this cube were water, how large would it be?

ant of them seem desirable.

21. Oxygen.—Oxygen is regarded as an immediate principle only when it exists in a free state, as it does in the blood, which, in an adult, contains sixty-one grains: nine and a half cubic inches being found in the arterial, and fourteen and a half in the venous blood.

25. Amount of Water Consumed Yearly by an Adult.—An adult drinks about fifteen hundred pounds of water yearly; and throws off through the various waste-gates nineteen hundred pounds. The difficulty of accounting for the four hundred pounds has led some to suppose that water is formed in the system by the union of oxygen and hydrogen.

26. Common Salt in the Body.—The salts that have been enumerated, are found in almost every part of the body. Common salt (Chlorid of Sodium) is found in every fluid and solid, except enamel. The whole amount in man is 277 grains. It subserves many important uses.

27. Carbonate and Phosphate of Lime, &c.—Carbonate of lime exists in considerable quantity in the bones, along with a much larger quantity of the phosphate of lime, and a small amount of phosphate of magnesia, and of fluoride of calcium. These salts, except the fluoride, are found in most other parts of the body.

28. Acids, Salts, &c.—Most of the acids and salts, the neutral nitrogenous compounds, the sugars, the fatty and saponaceous compounds, exist, or are formed in the fluids of the body, and though numerous (forty-two in all), their quantity is comparatively small. They are mostly formed by disassimilation in the body, and hence only their elements need to exist in our food.

29. Sugar in the Body.—Only two kinds of sugar exist, or are formed in animals. Grape sugar is found in the liver, in some of the veins, and other organs. In the disease called Diabetes, its quantity is very much increased, and, in fact, an excess of sugar in the system is a sign of serious derangement.

30. Fats in the Body.—The fatty principles, cholesterine, oleine, etc., exist in the body in cells, in chemical combina-

25. How much water does a man consume in a year? How much is thrown off during the same time? Explain the reason. 26. Where does common salt occur in the body? How many grains exist in the body? 27. In what parts of the body do Carbonate and Phosphate of Lime occur? 28. How many acids and salts are found? State how they are formed. 29. How many kinds of sugar are found in animals? What does an excess of sugar indicate? 30. How do the fats occur in the body?

tion with other substances, and as oil drops or fat globules not inclosed. These principles are mostly taken as food into the system, but they are most probably also formed there from elements; certainly, the liver has this power. One tenth of the brain is composed of fat; and it is only in the last stages of emaciation, that this supply is exhausted.

31. *Assimilation Necessary.*—The principles thus far described, constitute but a small proportion of the animal frame. But the organic, or coagulable principles, enter largely into its composition. Indeed, they form the principal source of nourishment. The most important of these principles (albumen, fibrine, and caseine) are in a fluid state in the body; the others are solid, or demisolid. Though the materials for their formation must exist in the food, yet there is reason to suppose that the process of assimilation is necessary, to transform them into these principles.

32. *Albumen, Albuminose, Caseine.*—Coagulation takes place when a liquid, or semi-liquid, passes into a solid state. The white of an egg gives a good idea of one kind of albumen (ovalbumen). Seralbumen exists in the blood, and in other liquids of the body. Albuminose is found in the same fluids, and has been, till of late, confounded with albumen. It is formed in the upper intestines, but when it passes into the blood, it becomes mostly albumen, sometimes musculine, fibrine, etc. Animal caseine is found only in milk, being most abundant when an animal diet is used. It contains from four to six per cent. of phosphate of lime, and hence the importance of milk for young animals, that their bones may be developed.

33. *Fibrine, Musculine, Globuline, Osteine, and Gluten.*—Fibrine is found in the blood, and when it coagulates, the mass is fibrous, the process being called fibrillation. It is this principle chiefly that causes blood to coagulate, the great importance

Is fat formed in the body, or taken in from the food? 31. State the three most important organic principles. 32. Define coagulation. What is ovalbumen, seralbumen and albuminose? In what is caseine found? What important ingredient does it contain? 33. Where is fibrine found? What causes coagulation of the blood? What practical benefit is derived from coagulation?

of which in arresting dangerous hemorrhages is well known. Coagulation appears to be a vital process, that is, dependent on life for its development, and not on chemical laws only. It can be prevented by any thing that destroys life, such as poisons, or a temperature too high, or too low. Fibrine does not exist in the muscles. That which has been called such is musculine, which is endowed with the vital property called contractility. Globuline occurs only in the red corpuscles of the blood. Osteine is the substance from which gluten is made, by the action of boiling water, for gluten does not naturally exist in the body. Osteine is the essential organic element in bone.

34. Hematine.—Hematine is the coloring matter of the blood, and though iron is found in connection with it, all the iron can be abstracted without destroying the color. Hence, that can not depend on the iron. Hematine is probably produced from certain red crystals, occurring in the red corpuscles. A group of these crystals is here shown.

FIG. 3.



35. Proteine Compounds.—All the organic or coagulable principles contain nitrogen, or rather, are composed essentially of oxygen, hydrogen, carbon and nitrogen. Hence, their value as food, since a greater part of the body is composed of these elements. Albumen, fibrine, and caseine have been termed Proteine Compounds, for they can easily be changed

—Is fibrine found in muscular tissue? What is the proximate principle of muscular tissue? Where does globuline and osteine occur? 34. What is the coloring matter of the blood? Has iron any thing to do with its color? What is the Hematine produced from? 35. What four simple elements make up all the organic principles? Why are albumen, etc., termed Proteine compounds?

into Proteine, a substance, however, which does not exist in nature, but results from the decomposition of the principles above named.

HISTOLOGY.

36. Organic and Inorganic Structure.—Animals and plants have a structure different from that of minerals when we examine them with the microscope. The former is called Organic, and the latter Inorganic Structure.

37. Vitality the Cause of Organization.—Vitality, or the principle of life, or the Vital Force, is the cause of organization. The nature of life is indeed involved in obscurity; but its effects are manifest, and among them is organization: although some have maintained, but without good reason, that the vital force is nothing but a peculiar manifestation of heat, mechanical force, chemical action, galvanism, etc.

38. Elementary and Primary Tissue.—The simplest forms of organized structure are three.

1. Simple Membrane.
2. Simple Fiber.
3. Cells.

These organic forms physiologists denominate Elementary Tissue. When united, they form Primary Tissue.

39. Histology; Proportion of Tissues in the Body.—Histology is the science of Tissues. Tissue forms nearly the whole of the solid portions of the body. By means of the microscope, they have been examined with great care, and described.

40. Fluids of the System; Hygrology.—Before entering upon a description of the tissues, it seems desirable, at least, to enumerate the different fluids found in the system, though a

36. Define organic and inorganic structure. 37. Give the cause of organization. 38. State the three simple forms of organized structure. What is Elementary Tissue? What is Primary Tissue? 39. Define Histology. What forms the solid parts of the body? 40. What is Hygrology?

fuller description of them will be given further on. These fluids contain the elements of the tissues. That part of anatomy which treats of them is called Hygrology.

41. *Lymph*.—Lymph, a transparent, coagulable fluid, in the lymphatics, emptying into the blood.

42. *Chyle*.—Chyle, a white, coagulable fluid, derived from the food in the intestines, and conveyed to the blood.

43. *Blood*.—Blood, in the veins and arteries, from which nearly all the parts of the system are sustained, a coagulable fluid, with an alkaline reaction.

44. *Serum*.—Serous secretions, fluids found on various serous membranes, as the pleura, peritonæum, pericardium, and membranes of the brain and ear.

45. *Transudations*.—Transudations, vapor from the lungs, and sometimes from the skin; also, fluids in some of the tissues, more especially in certain diseases, as dropsy in the head, chest, and abdomen, certain sweats and discharges in cholera, etc.

46. *Exudations*.—Exudations, “any organizable fluid spontaneously separated from the blood vessels, without rupture of their walls,” chiefly occurring in inflammations, and wherever new material is required for repair of the system. The pus of wounds and sores is an example of exudation.

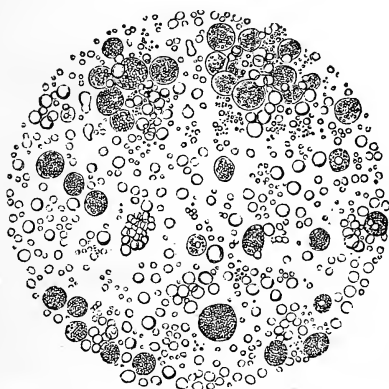
47. *Mucus*.—Mucus, a viscid mass capable of being drawn into threads, secreted from the mucous membrane, but differing in different parts.

48. *Gastric Juice and Pepsin*.—Gastric fluid, a fluid secreted by the stomach, containing a substance called Pepsin, which aids in digestion. It contains a little free chlorohydric and lactic acids.

41. What is Lymph and what becomes of it? 42. Define Chyle and state what becomes of it. 43. Define the blood. 44. What membranes secrete the serum? 45. Define transudations. In what diseases do they occur? 46. What are exudations? When are they serviceable? 47. What does the mucous membrane secrete? 48. Define and describe the secretions of the stomach.

49. **Intestinal Fluid.**—The intestinal fluid, a colorless, tenacious fluid, with strong alkaline reaction, whose function is to assist in digestion. Secreted by the epithelial cells of the intestinal follicles.

FIG. 4.



50. **Milk.**—Milk, a glandular secretion, showing under the microscope an immense number of fat globules, suspended in a clear fluid, as in fig. 4.

51. **Saliva.**—Saliva, a secretion chiefly from the parotid and submaxillary gland into the mouth, to assist in digestion.

52. **Bile.**—Bile, a greenish or brownish

bitter fluid, secreted by the liver to assist in digestion.

53. **Pancreatic Juice.**—Pancreatic fluid, a colorless, tasteless, but somewhat alkaline fluid, secreted by the pancreas to aid in digestion.

54. **Urine.**—Urine, secreted by the kidneys.

55. **Tears.**—Lachrymal fluid for lubricating the eyeballs, secreted by the lachrymal gland.

56. **Oil and Wax.**—Sebaceous secretions, fatty fluids thrown out by what are called the sebaceous follicles of the skin, to keep it moist.

57. **Sweat.**—Perspiration, or sweat, a colorless, watery

49. What is the Intestinal fluid? 50. How does milk appear under the microscope? 51. What is the origin and use of saliva? 52. State the secretion of the liver. 53. &c., Describe Pancreatic Juice. Urine. Tears. Oil and Wax. 57. From what glands is sweat produced?

fluid, with a saltish taste, and having odor, secreted from the perspiratory glands.

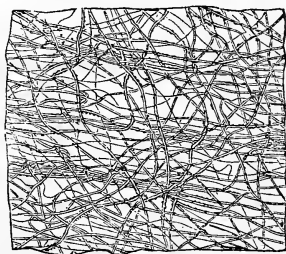
ELEMENTARY TISSUES.

58. Simple, or Basement Membrane.—1. *Simple Membrane*. This is usually a structureless layer of coagulated albumen, often not more than $\frac{1}{200000}$ th of an inch thick. It forms the walls of all cells, and is also spread out, as an inferior layer of the skin and mucous membrane, and is then called basement membrane. It is the most simple of all the tissues, yet it is the agent of secretion, and sometimes of absorption, and these Professor Peaslee considers as its vital properties, though of a low grade.

59. Imbibition.—Simple membrane also possesses the remarkable property of allowing fluids to pass through it when it is placed between two fluids; the effect depending in part upon the electro-chemical relations of the substances, but not, as generally supposed, on the difference of specific gravity of the liquids. This is called endosmose and exosmose, or Imbibition, and is the principal means by which fluids are made to pass from one part of the system to another, where no distinct vessels are provided for that purpose.

60. Simple Fiber.—2. *Simple Fiber*. This consists essentially of threads of coagulated fibrine, whose average diameter is about $\frac{1}{25000}$ th of an inch thick. It does not appear to be a permanent constituent of the body, but only a basis for the development of the more complicated tissues. A good example of the simple fiber may be seen in the membrane lining the inside of an egg shell, as in Fig. 5.

FIG. 5.



58. What is simple membrane? How thick? Where is it found? What other name is given to it? 59. Describe Imbibition. What purpose does it effect? 60. Describe simple fiber. Its size. Where best seen?

61. **Shape of Cells.**—3. *Cells.* These are merely membranous bags, or vesicles, from $\frac{1}{200}$ th to $\frac{1}{6000}$ th of an inch in diameter, filled with some kind of liquid, or solid substance. When free, the form is spherical, or spheroidal, as in Fig. 6. But, as they press against one another, they are brought into a polyhedral form, as in Fig. 7, showing a group of fat vesicles.

FIG. 6.

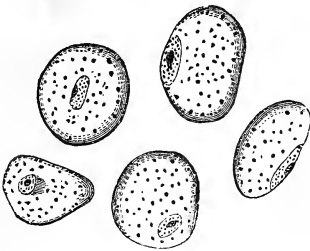
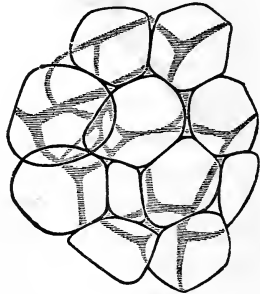


FIG. 7.



62. **Contents of Cells; Granules; Nucleus and Nucleolus.**—The fluid of cells is transparent, except in the case of blood. In it there generally float an immense number of granules, having no investing membrane, but sometimes they are thus invested. Each cell has also a nucleus and a nucleolus; the first being a globular, or lenticular body, from $\frac{1}{6000}$ th to $\frac{1}{2000}$ th of an inch in diameter, attached to, or imbedded in the wall of the cell, though some are free. The nucleolus is a granule within the nucleus. Both are shown, as well as the common granules, in Fig. 6.

63. **Appendages of Cells.**—Sometimes cells have a sort of tail attached to them, and are hence called caudate, as in Fig. 8. Sometimes, too, they are stellate, as in Fig. 9, showing the pigment cells of a frog's foot.

61. Define cells. What is the original form of them? How do they acquire the polyhedral form? 62. Explain nucleus, nucleolus and cell wall. 63. What are the appendages of cells?

FIG. 8.

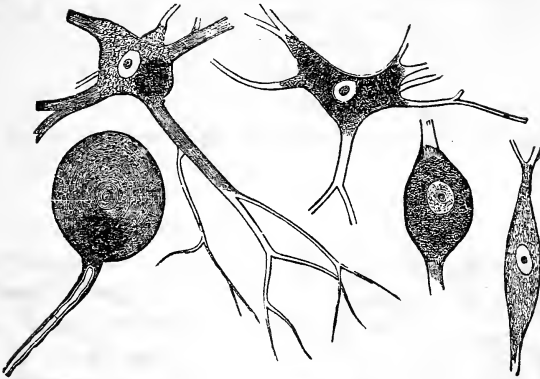
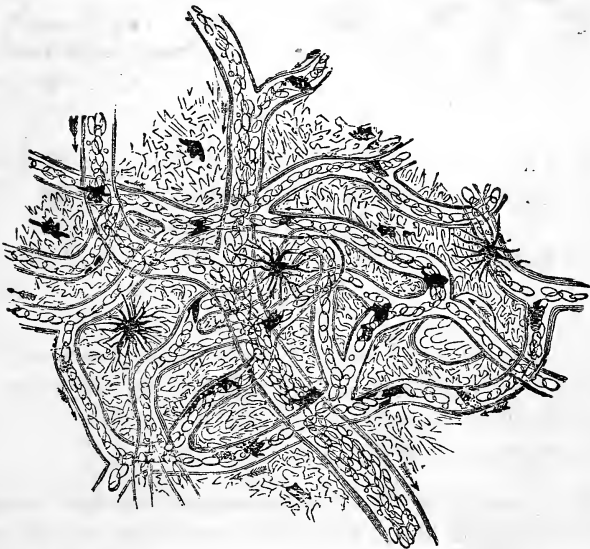


FIG. 9.



64. Cytogenesis.—The cell is the most important of the elementary tissues, for, by its multiplication, most of the other

64. Give the process by which cells increase and form tissues.

tissues in animals and vegetables are made up. This is called cytogenesis. The increase usually takes place by duplicative subdivision, which is shown on Fig. 10. The cell *a a* first becomes elongated, as at *b*, and then it divides at *c c*. The subdivision going on will give an increase in rapid ratio—2, 4, 8, 16, 32, etc. Fig. 11 shows an example of this division,

FIG. 10.



A, B, C, D, in its earlier stages, and E, F, G, H, in its more advanced condition.

Sometimes cells multiply by the development of new cells in the interior. In this case the nucleus subdivides into two or more portions, which at length fill the original cell, as is shown in Fig. 12. Sometimes cells are formed by the expansion of homogeneous

FIG. 11.

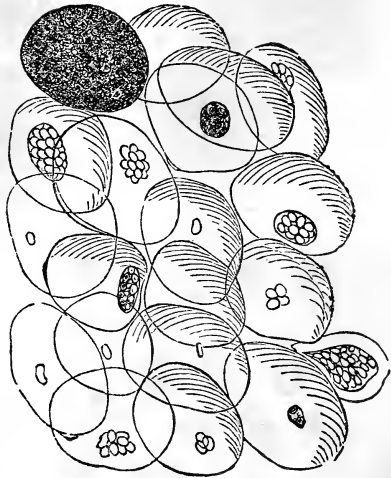


granules into cells; or they are even produced in the midst of a formative fluid (called a blastema), poured out from the blood.

Describe the mode of formation as illustrated in Figures 11 and 12. What is the Blastema?

65. It is in these ways that most of the tissues of the body are built up, and the animal enlarges to its full size. It has been maintained that all the tissues originate in cell development. But, in some cases, simple fibers and membranes seem to be formed directly out of an organizable substance, without the intervention of cells.

FIG. 12.



66. Vital Force of Cells; Chemical Transformations; Vitalization of the Cells; Change of Form; Development of Nerve Force.—The multiplication of cells is one of the manifestations of the vital force inherent in them. Another is the chemical transformations exerted upon the contents of the cell in some instances, whereby new products are generated. Another is the vitalization of a portion of the cell contents, whereby they are able to produce new cells. Another is permanent changes of form in connection with growth. Another is temporary changes of form, accompanied with sensible motion, as in the oscillatory movements of the leaves of *Hedysarum gyrans*, and the folding of the leaves of the *Mimosas* upon touch. Finally, the development of nerve force from cells, by which all the bodily operations may be modified, and which is intimately connected with mental agency.

67. Periods in the Life of the Cells.—In cell life there is a

65. Show how the tissues of the body are made up. 66. Mention the different changes which cells undergo.

period of augmentation, another of perfection, another of decline, and, finally, one of cessation. So long as vitality can use chemical and physical agencies for building up the system, they tend to its preservation, but, when life ceases, they tend to its destruction, not, as is generally thought, because the vital principle has not the power of resisting these agencies, but because it can no longer turn them into the channel for preserving the system.

PRIMARY TISSUES.

The chief mass of the animal system is made up of the elementary forms that have been described, variously combined so as to form plexuses and webs, which are called primary tissues by some, and compound tissues by others. They are differently classified by different writers. The arrangement which follows is that of Professor W. B. Carpenter:

1. SIMPLE FIBROUS TISSUES.

68. White and Yellow Fibrous Tissues.—This embraces the white and yellow fibrous tissues, as well as the areolar or connective tissue of other writers. The white fibers are from $\frac{1}{50000}$ th to the $\frac{1}{20000}$ th of an inch in diameter, and form the tendons, ligaments, and fibrous membranes. (Fig. 13.) The

FIG 13



FIG. 14



67. Give the four different periods in the life of cells. 68. Give the size of the fibers of white and yellow fibrous tissues.

yellow fibers are about $\frac{1}{75000}$ th of an inch in diameter and form a part of the larynx, and the middle coat of the arteries.

69. **Areolar Tissue.**—The areolar tissue consists of fibers of white and yellow tissue interwoven, so as to leave irregular spaces, or areolæ, between them. This tissue originates from cells, as is shown in Fig. 16. The areolar tissue is more widely diffused than any other in the body, so that if it were possible to remove all but this one, the form of the part would be preserved. It surrounds all the arteries and veins, the nerves, muscles and internal organs; and it forms one of the layers of the skin and mucous membrane.

FIG 15.

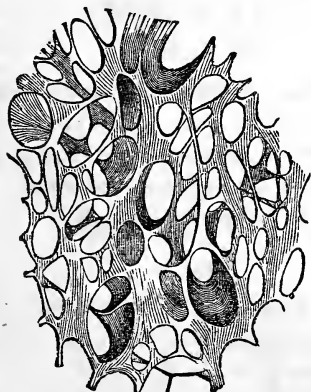
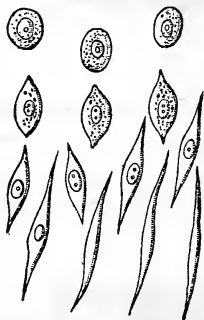


FIG. 16.



2. THE FIBRO-CELLULAR MEMBRANES.

70. One of the layers of the skin, of the mucous membrane, and the serous and synovial coat that lines the shut cavities of the body, is composed of interwoven fibers of simple basement membrane, and of one or more layers of cells upon the free

69. What is the composition of areolar tissue? What of its abundance in the body? Where is it principally found? 70. Describe the fibro-cellular membrane.

surface. This is the fibro-cellular membrane or tissue. Its position and character will be better understood when the parts above referred to have been described in subsequent sections.

FIG. 17.

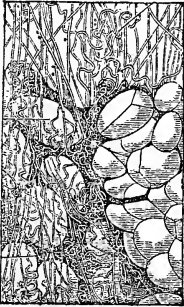
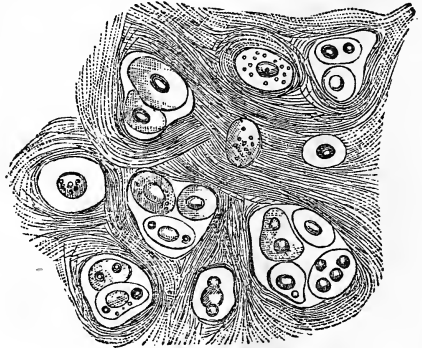


FIG. 18.



3. CELLULAR TISSUES.

71. Fat and Cartilage.—These embrace the adipose tissues, Fig. 17, and the cartilaginous, Fig. 18. The first is the usual form of fat, wherever it occurs in the system. It retains the pure form of the primitive cells. In cartilage, also, these cells sometimes exist alone, but more frequently they are interwoven with fibers, as seen by the figures.

4. SCLEROUS TISSUES.

72. Bones and Teeth.—These constitute the bones and teeth, and are composed of an animal basis of fibers and cells cemented together by phosphate and carbonate of lime. Fig. 19, which is a transverse section of one of the bones of the arm, will give an idea of the arrangement of the animal matter, the earthy part having been dissolved by acid. Fig. 20 shows a transverse section of the shoulder blade, exhibiting the dark spaces called lacunæ.

71. Describe fat and cartilage. 72. What is the composition of the bones and the teeth? 73. What are the capillaries and absorbents? Give the size of the capillaries.

FIG. 19.



5. TUBULAR TISSUES.

73. Capillaries and Absorbents. — These form those minute blood vessels called capillaries, and others called lymphatics or absorbent vessels, which exist in every part of the body, and are distinct from, although connected with, the arteries and veins. The capillaries connecting these are from $\frac{1}{2500}$ th to $\frac{1}{3700}$ th of

FIG 20.

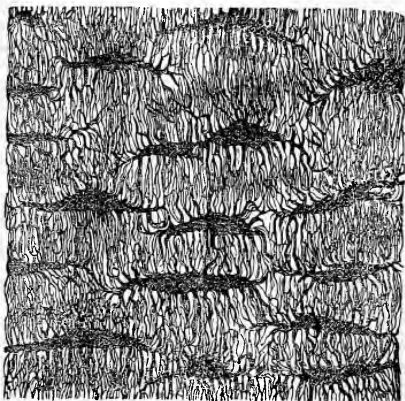


FIG. 21. an inch in diameter, less often than the blood corpuscles. In some other animals they are larger, as may be seen in the capillary plexus of a frog's foot, shown in Fig. 9. The lymphatics abound with valves, as may be seen in Fig. 21.



6. MUSCULAR TISSUE.

74. Striped and Smooth Muscle.—This tissue is made up of two forms of fiber, the striped and unstriped. The stripes in the first form run both transversely and longitudinally, as may be seen

FIG. 22.

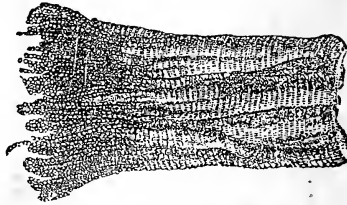
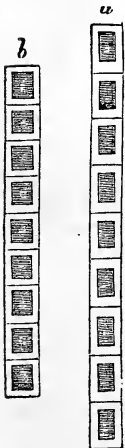


FIG. 23.

in Fig. 22. When separated longitudinally, the fibrillæ have a beaded appearance, each bead being in fact a cell, as is here represented in Fig 23, which shows the cells *a* when most relaxed, and *b* when most contracted. Muscular fiber is capable also of being divided crosswise in the direction of the transverse striæ into discs, as seen in Fig. 24. Both the striated (striped) and non-striated muscles originate in cells. Figs. 25 and 26 show their development.



75. Myotility.—The grand peculiarity of muscular tissue is its power of contraction—a phenomenon as mysterious and wonderful as any thing in nature. This is called myotility or contractility.

What do the lymphatics abound in? 74. Distinguish between the striped and the unstriped muscular fiber. Give the reason of the difference between *a* and *b* in Fig. 23. 75. Define myotility.

FIG 24.

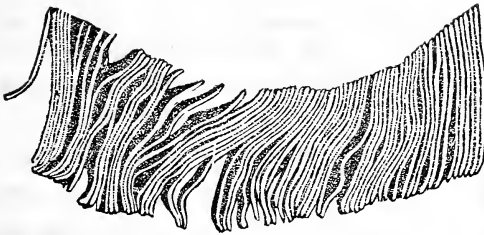
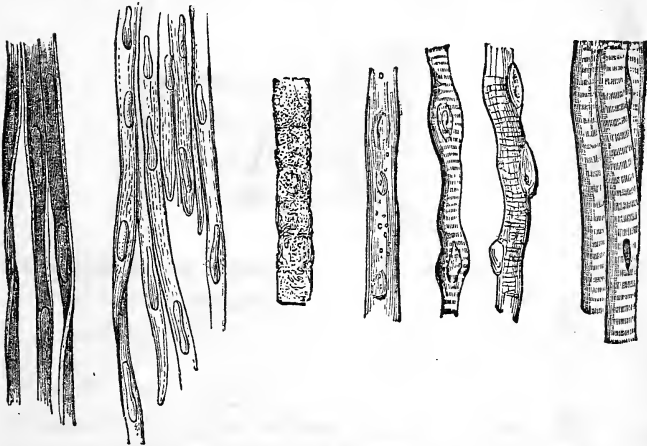


FIG. 25.

FIG. 26.



76. The Chemical Composition of Muscle.—The chemical composition of the muscular tissue is almost exactly the same as that of blood, as the following analysis will show :

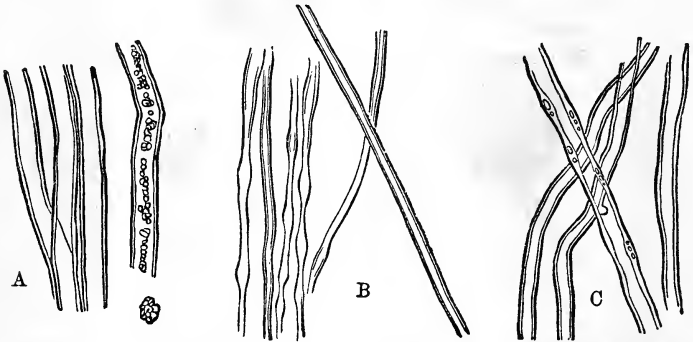
	Blood.	Muscle.
Carbon.....	51.83	51.95
Hydrogen.....	7.67	7.17
Nitrogen.....	15.01	15.07
Oxygen.....	21.36	21.39
Ashes.....	4.23	4.52
	<hr style="width: 50%; margin: 0 auto;"/> 100.00	<hr style="width: 50%; margin: 0 auto;"/> 100.00

76. State the chemical composition of muscle.

7. NERVOUS TISSUE.

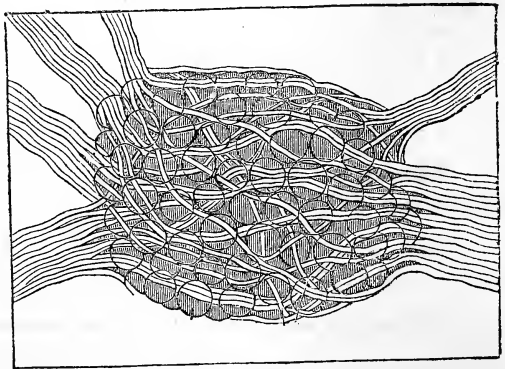
77. Nervous Tissue; Tubular Cells.—This, like some of the other tissues, is composed of cells, fibers and tubes, but it is distinguished from all others by its vital endowments. In the ordinary nerve trunks the tissue is the fibrous or tubular, as is shown in fig. 27, A, B, and C. In C some of the original cells are shown.

FIG. 27.



78. Vesicular Cells; Granular Cells.—In those nervous masses called ganglia, we find, in addition to the fibers, a substance made up of vesicles or cells, as is shown in the ganglion of a mouse on fig. 28.

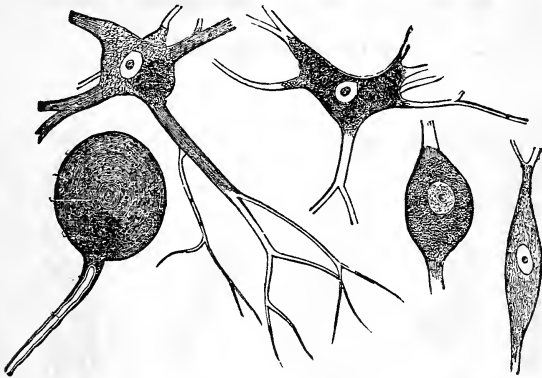
FIG. 28.



77. How is nervous tissue to be distinguished from all other tissues? 78. Describe the vesicular cells.

Another primary element of the nervous system is composed of nucleated cells, containing a finely granulated substance. These sometimes have processes which give them a caudate or stellate form, as in Fig. 29.

FIG. 29.



79. An Organ. The System.—Such are the tissues which, combined in various proportions, make up the organs of the human body. And by the term organ we mean a part usually composed of several tissues adapted to certain functions. And though harmoniously united into a single system, that is, the body, the anatomist can dissect and describe them separately. In this work the following order will be adopted :

1. *Osteology*, or an account of the Bones or framework of the system.
2. *Myology*, an account of the Muscles or the moving powers of the system.
3. *Splanchnology*, or the Nutritive Organs.
4. *Angiology*, an account of the Circulating System of the arteries and veins.

5. *Pneumonology*, or an account of the Respiratory, Vocal, and Calorific Organs.
6. *Ichorology*, or the Lymphatic and Secreting System.
7. *Neurology*, or the history of the Nervous System, the vivifying power.
8. The Inlets of the soul, or the Senses.
9. Religious teachings of the subject.

CHAPTER FIRST.

THE FRAMEWORK OF THE SYSTEM.—OSTEOLOGY, OR A DESCRIPTION OF THE BONES.

DEFINITIONS AND DESCRIPTIONS.

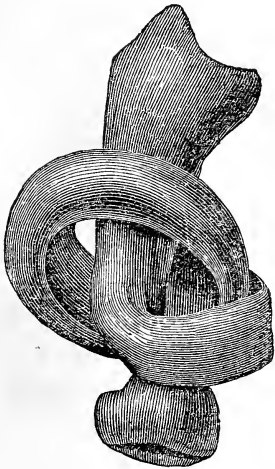
80. **Chemical Composition of Bone.**—The Bones of all vertebrate animals are principally composed of the Phosphate and Carbonate of Lime, and, with the exception of the Teeth and articular extremities, are closely covered by a firm membrane called the Periosteum. By chemical analysis the composition is as follows :

Organic substance (Osteine or Cartilage)	33.00
Phosphate of Lime.....	57.00
Carbonate of Lime.....	8.00
Fluorid of Calcium.....	1.00
Phosphate of Magnesia.....	1.00
	<hr/>
	100.00

81. **Cartilage and Salts of Lime shown.**—Hence we see that the principal constituents of bone are the salts of Lime and Cartilage. The former can be easily obtained by burning the bone a while in a hot fire, which appears like a white powder when crushed. The Cartilage is obtained by immersing it for a considerable time in a dilute acid, when we have the form of the bone perfectly retained, although nothing is left but cartilage. Its elastic character may be inferred

80. What are the principal ingredients of bones? Where is the Periosteum found? Give the chemical analysis. 81. How can the earthy ingredients be shown? The cartilage?

FIG. 30.



from Fig. 30, which is a human Fibula tied in a knot after having been immersed for some time in muriatic acid.

82. Mechanical Construction of Bones.—As a general law the extremities are the largest, and the bodies or shafts are smooth and of a uniform surface. They are in most cases so constructed as to give the greatest strength and support, and at the same time furnish as little weight as possible. Hence the long bones are mostly hollow, or have an arched form, while the flat bones are

portions of a circle or sphere. In the face also the bones are not all solid, but some of them contain large cavities, so that firm attachment may be given to the muscles, and protection to the more delicate parts.

83. Average Weight of adult Skeleton.—The weight of the skeleton is as 10.5 : 100, or about one tenth the weight of the whole body. And since the average weight of an adult man is 136 pounds, the weight of an adult skeleton is about 13.5 pounds.

84. Strength of Bones.—The power of the human bones as levers when compared with different substances is remarkable, as is seen by the following table.

Freestone (sandstone).....	1.
Lead	6.5
Elm and Ash (wood).....	8.5
Box, Yew, and Oak	11.
Human Bone.....	22.

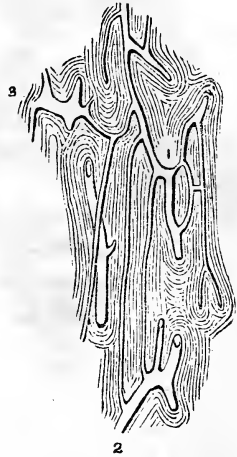
82. Which part of the bones is generally the largest? Why are many of the bones hollow or partially so? 83. Give the weight of the human skeleton. What is its proportion to that of the whole body? 84. Give the comparative strength of the bones.

That is, bone when used as a lever is 22 times as strong as Sandstone, $3\frac{1}{2}$ times as strong as Lead, nearly $2\frac{3}{4}$ times as strong as Elm and Ash, and 2 times as strong as Box, Yew, and Oak timber.

85. Microscopic Structure of Bone.

Haversian Canals.—Examined by the microscope the bones are found to be made up of plates or layers for the most part, arranged concentrically in the long bones, and in parallel layers in the flat ones. These are traversed in all directions, and especially in their long diameters, by minute tubes or vessels called Haversian canals, which are also encircled by several laminae or plates besides those following the general outline of the bone. Fig. 31. These canals have a diameter varying from $\frac{1}{1200}$ to $\frac{1}{240}$ th of an inch, while the accompanying lamellae show a thickness of $\frac{1}{600}$ th of an inch. They sometimes contain a capillary vessel, but more usually carry only the nutritive and watery portion of the blood.

FIG. 31.



Transverse section of bone magnified 15 diameters. 1, Outer layer. 2 and 3, inner layers.

86. Lacunæ, Canaliculi.—Besides these canals we find a smaller set of vessels or cells located directly in the substance of the concentric lamellae, called Lacunæ or Bone Corpuscles, which average $\frac{1}{1000}$ th of an inch in length, and carry the fluid which nourishes the bone. These are of a black appearance, of an oval form, and with rays divergent in all directions, as

85. How are the particles of matter arranged in the long bones? How in the flat ones? Describe the Haversian canals. Their diameter. What vessel does each one contain and what is the purpose of that vessel? 86. What are the Lacunæ or Bone Corpuscles?

FIG. 32.



Lacunæ of Bone. *a*, central portion.
b, canaliculi or Bone Pores.

seen in Fig. 32. These rays are minute canals, and nearly all of them anastomose, or have communication with each other. They are called Canaliculi, or Bone Pores, and measure $\frac{1}{30000}$ th of an inch in diameter.

87. Ultimate Granules.—The ultimate histological element, or the smallest element of bones as yet

FIG. 33.



discovered, is made up of pale oval granules, about $\frac{1}{60000}$ th of an inch in diameter. These granules constitute all the substance of the bone except the minute vessels already mentioned.

88. Hence the microscopic elements of bone are four :

1. Haversian Canals.
2. Lacunæ or Bone Corpuscles.
3. Canaliculi or Bone Pores.
4. Ultimate Granules.

89. Periosteum.—In all parts of the body, both solid and fluid, we find that nature has made ample protection by providing for nearly every organ a firm membranous sheath. This not only serves as a protection and support, but in many cases a means of nutriment. Upon the bones accordingly we find a very firm whitish yellow membrane closely attached to them in most places, and very smooth, called the Periosteum. This occurs on every part of every bone, except at the articulations, and upon the crowns of the teeth. It is, when healthy, perfectly insensible, and contains the vessels which ramify into the bones, being in fact the

What are the Bone Pores or Canaliculi? 87. What is the smallest or ultimate element of bones? 88. Give the four microscopic elements of bone. 89. What is the color of the Periosteum? On what part of the bones is it wanting? What two important purposes does it subserve?

nutrient membrane of the bones. Besides this function, the periosteum serves as a point of attachment for the ligaments and tendons, in as much as they could not find firm attachments on the bone itself.

Remark.—Diseases of Periosteum.—In the diseases known as Felon and Fever Sore, the Periosteum is the seat of the inflammation, although, if it be not soon checked, the bone itself becomes implicated.

90. Processes of Bones.—The bones of animals are not constructed after any regular geometrical form or curve, but are modeled upon the plan which may secure the greatest firmness and facility of motion. Accordingly we find their surfaces quite uneven, presenting in many places prominent projections, which serve as a firm point of attachment for muscles and ligaments. These are called Processes, and are generally found near the extremities of bones, and are largest where the greatest strength of muscle and ligament is required, as shown in the bones of the lower extremities.

91. Nutritious Foramina.—Upon nearly all the bones of the body may be found small tubular openings which, after extending for a short distance into the bone, ramify and give off the minute capillary vessels which circulate through the larger Haversian canals. They are called nutritious foramina, or openings, since they convey nutriment to a large portion of the bone.

92. Four Classes of Bones.—Bones are divided according to their shape into four classes: long, flat, short, and irregu-

FIG. 34.



Periosteum of a humerus partly taken off.

What is the seat of Felon and Fever Sore? 90. What is the general outline of bones? What are Processes? 91. What are the nutritious foramina, and with what vessels do they communicate? Their use? 92. Give the four classes of bones, and give examples of the long ones.

lar. The long ones are mostly found in the extremities, and consist of a hollow shaft with enlarged and partially smoothed extremities, and sometimes a rough or elevated portion along their central portions. Those which belong to this class, are the Clavicle, Humerus, Radius, Ulna, Femur, Tibia, Metatarsus, and Metacarpus, Phalanges and Ribs.

93. **Short Bones.**—The Short bones are irregularly cuboid in form, and are found in those places where there is but little motion of the part. They are the Vertebrae, Coccyx, Carpus and Tarsus, Patella, and Sesamoid bones.

94. **Flat Bones.**—The Flat bones are arranged to enclose and protect cavities. Those of the head are made of two layers of bony matter, with an intervening porous substance called the *Diplôè*. These are the Occipital, Parietal, Frontal, Nasal, Lachrymal, Vomer, Sternum, Scapula, and the *Os Innominatum*.

95. **Irregular Bones.**—The Irregular bones are those which belong to neither of the preceding classes, and have no typical form. They are the Temporal, Sphenoid, Ethmoid, Superior and Inferior Maxillary, Palate, Turbinate, Hyoid, and Sacrum.

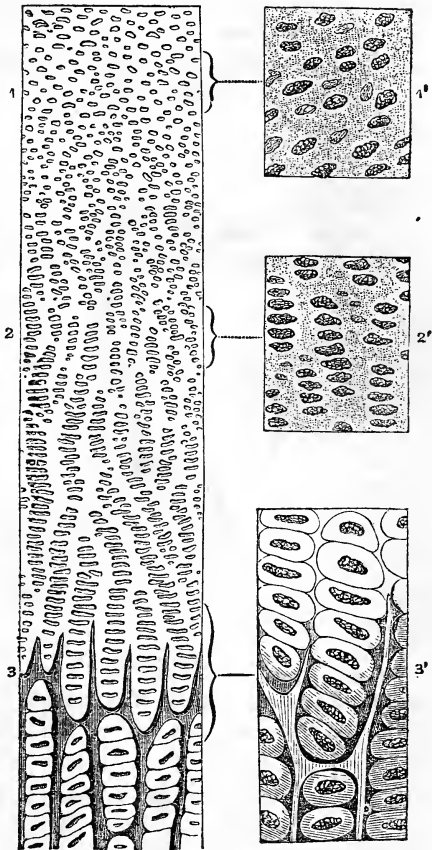
96. **Development of Bone from Cartilage.**—The early condition of bone is that of cartilage, which has the general outline of the bone, and from the subsequent process may be called the mould of the bone. Very early in life, and even before birth, bony matter begins to be deposited in the cells of the matrix (cartilage) until at length, the whole becomes solid, as it is found in adults. At birth the only bone which is completely ossified is that portion of the temporal called the petrous, which contains the organ of hearing, while all the bones are not completely ossified before the 12th year of life. This process of hardening, or os-

93. What is the general outline of short bones and where are they found? Give examples. 94. Give the use of the flat bones. Examples also. 95. What are some of the irregular bones? 96. What is the first stage of bone? When is the process of ossification complete? What bones are the first that become ossified?

sification, begins at certain points, and continues until the whole is completed as is seen in the Fig. 36. In some of these bones there is but one of these centers, or points, where ossification commences, while in the Sphenoid there are 12.

97. Number of Bones.—The number of bones in the human system is reckoned differently by different anatomists since many of the bones are well exhibited only in hard working or well developed muscular subjects. The number 246 will be given in this book as taken from Erasmus Wilson, whose work on Anatomy is adopted as the text

Fig. 35.

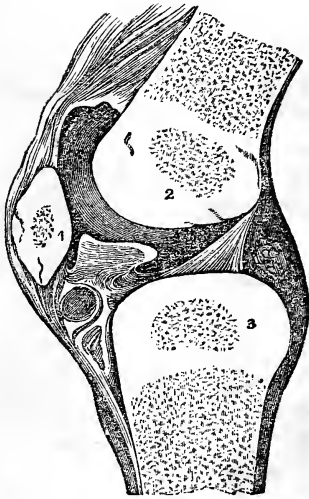


Section of cartilage near the point of ossification. 1, ordinary appearance of cartilage. 2 and 3, more advanced stages of ossification. 1', 2' and 3' portions 1, 2 and 3 more highly magnified.

book in nearly all the medical schools of this country. This includes the teeth, and sesamoid bones, of which the latter are not constant in every individual. They are summed up as follows:

97. What is the number of bones in the human body? Give the different groups.

FIG. 36.

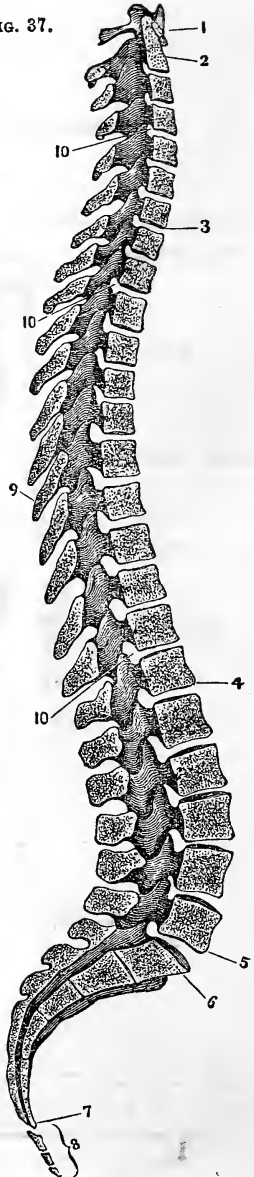


A knee joint showing points of ossification, 1, 2 and 3.

Head.....	8
Ear.....	6
Face.....	14
Teeth.....	32
Vertebræ, Sacrum and Coccyx....	26
Os Hyoides, Sternum and Ribs....	26
Upper Extremities.....	64
Lower Extremities.....	62
Sesamoid Bones.....	8

246.

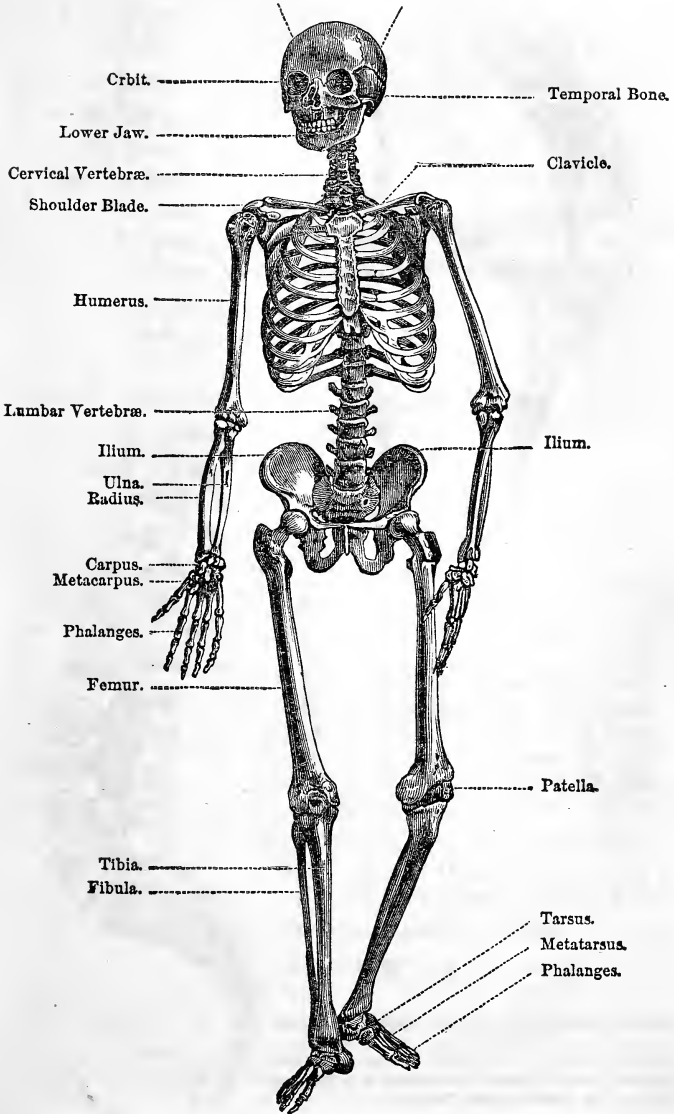
FIG. 37.



98. *Vertebræ, Groups of Vertebrae, Cervical Vertebrae.*—The Vertebrae or Spinal Column claim the first attention, since they are the

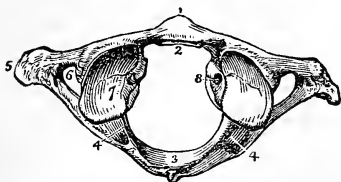
Description of Fig. 37. Lateral view of the Spinal Column. 1, Atlas. 2, Axis (second Vertebra.) 3, Last Cervical Vertebra. 4, Last Dorsal Vertebra. 5, Last Lumbar. 6 and 7 Sacrum. 8, Coccyx. 9, a Spinous Process. 10, Intervertebral Foramina.

Frontal Bone. FIG. 38. Parietal Bone.



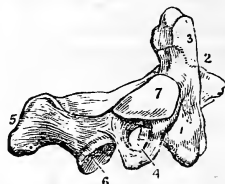
first developed bones, and the center around which the others are formed. They may be separated into the true and false: or those which are separable from, and movable upon each other, and those which are firmly joined together. Of the true vertebræ there are three sections, named in accordance with their location on the body: Cervical, Dorsal, and Lumbar. The Cervical, or those of the neck, are seven in number, the first and second of which are the most remarkable. The first is named Atlas, from the mythological story that a giant of this name supported the earth on his shoulders, and it is

FIG. 39.



The Atlas. 1, Anterior Tubercle. 2, Articular Face. 3, Posterior surface of Spinal Canal. 4, Intervertebral Notch. 5, Transverse process. 6, Foramen for Artery. 7, Superior oblique process. 8, Tubercle for transverse Ligament.

FIG. 40.



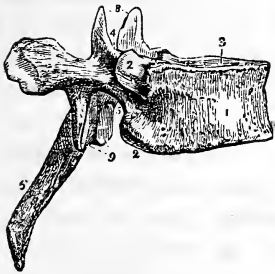
The Axis. 1, Body. 2, Processus dentatus. 3, Articulating surface. 4, Foramen for vertebral Artery. 5, Spinous process. 6 and 7, Oblique processes.

upon this one that the head is moved in a direction backwards and forwards. The second, called Axis, is characterized by a projection or pivot, which admits motion of the head in a horizontal direction, but in no other. It is the dislocation of this process, and the consequent pressure upon the spinal cord that causes death in criminals executed by hanging.

99. Dorsal Vertebræ.—The Dorsal Vertebræ, or those of the back, are twelve in number, and give attachments to all the ribs. The central portion or body of each increases from above downwards, that they may more firmly support the superincumbent weight of the body.

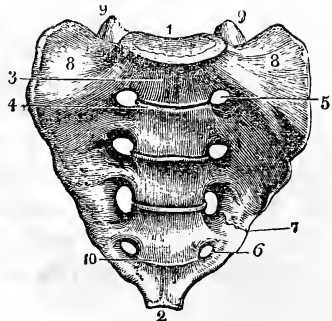
98. Why are the Vertebræ first described? What two groups may they be divided into? What other three sections of Vertebræ? What is the name of the first and second Vertebra? 97. How many Dorsal vertebræ, and what bones are attached to them?

FIG. 41.



A Dorsal Vertebra. 1, The Body. 2 and 7, Faces for head and tubercle of Rib. 8, Upper face of the body. 4 and 5, Intervertebral Notch. 6, Spinous process. 8 and 9, Oblique processes.

FIG. 42.



The Sacrum. 1 and 2, Articular surfaces. 3, Promontory of the Sacrum. 4 and 10, Lines of former division of Sacrum. 5 and 6, Foramina. 7, Sacro Ischiatic Notch. 8, Alæ of the Sacrum. 9, Oblique processes.

100. Lumbar Vertebrae.—The vertebrae of the Loins, or the Lumbar, are five in number, and are the largest members of the spinal column, since they are the only bones in this part of the body. They are more massive and solid in all their parts than the rest of this column, that they may be equal to the strength required of them.

101. Sacrum.—The Sacrum is a single bone, although its typical form is that of five vertebrae, which are actually found in some animals. Its appearance is that of five vertebrae, which are partially ankylosed or grown together. The form of the bone is somewhat like a wedge, with the base directed upwards, and the point curving inwards and forwards.

102. Coccyx.—The Coccyx is the lower extremity of the Spinal Column, formed of four ankylosed and imperfect vertebrae; and it is an extension of these bones in the monkey which makes the tail.

FIG. 43.



The Coccyx. 1, First bone. 2, 3, Processes to join the Sacrum. 4 and 5, Notches to form Foramen. 6, Last bone.

100. How many Lumbar Vertebrae? Why are they the largest in size? 101. Describe the Sacrum. How many rudimentary vertebrae does it consist of? 102. Describe the Coccyx.

103. **General Remarks on the Spinal Column.**—The Spinal Column viewed as a whole may be considered as made up of four cones, owing to the different sizes of the vertebræ. The apex of the upper one commences with the Atlas and extends as far as the first dorsal vertebra. Here the second one commences in an inverted position, extending over the upper three dorsal vertebræ. The third reaches with its base as far as the top of the Sacrum, where the inverted fourth one terminates with the Coccyx. Viewed from the front the spinal column should be in a straight line when in a healthy condition; but a lateral view shows two curves, one at the lower part of the neck, and the other at the lumbar vertebræ, the design of this curvature being to place the head and its delicate contents upon an elastic and flexible support, and the design of the straight position in the other direction, being to give equal tension to the muscles on both sides.

104. **Intervertebral Cartilage.**—Between all the vertebræ is placed a thick cushion of cartilage. This by yielding not only allows a free and ready motion to the column as a whole, but is an additional protection to the brain, by diminishing the severity of any vibration communicated from below.

105. **Bones of the Head.**—The Skull may be considered as the superior expansion of the spinal column, when it—the spinal column—is taken as the center of development of the whole body, which contains in the cranium the brain, and in the face most of the organs of sense.

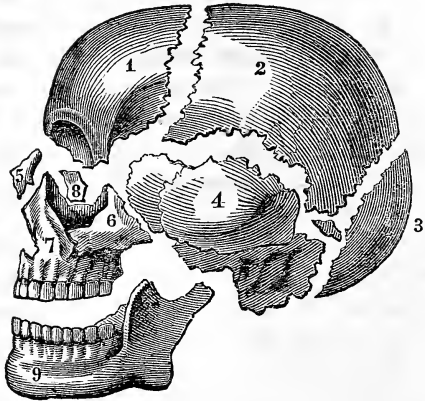
106. In the Cranium or true skull are eight bones:

1 Frontal,	2 Temporal,	2 Parietal,
1 Occipital,	1 Sphenoid,	1 Ethmoid.

103. Of how many cones may the Spinal Column be considered as composed? From what direction does the Spinal Column appear in a straight line? What curvatures does a lateral view show? 104. What substance do we find between the vertebræ? Give its use. 105. What may the Skull be considered as? What organs does it contain? 106. Give the bones of the Skull.

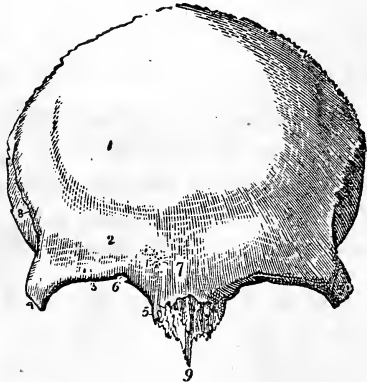
107. Frontal, Temporal, Parietal, Occipital, Sphenoid, and Ethmoid Bones.—The Frontal Bone is situated in the upper and front part of the head, occupying that portion of the skull called the forehead. It is mainly a flat bone, but the portion lying above the eye is hollow, in order that protection may be afforded to this delicate organ, as well as to give sufficient prominence to the upper part of the face. The two Temporal Bones cover the front part of each side of the skull in that position commonly known as the temples, and each bone is a little larger than the space which is protected by the external ear. In the inner portions, called the petrous, are located the organs

FIG. 44.



1, Frontal. 2, Parietal. 3, Occipital. 4, Temporal. 5, Nasal. 6, Malar. 7, Upper Jaw. 8, Lachrymal. 9, Mandible.

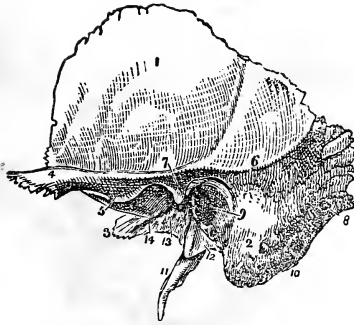
FIG. 45.



Frontal Bone. 1, Frontal Protuberance of right side. 2, Superciliary ridge. 3, Superorbital ridge. 4 and 5, Angular processes.

107. What kind of a bone is the Frontal? Why is a portion of it hollow? Where are the Temporal Bones located?

FIG. 46.



Left Temporal Bone. 1, Squamous portion. 2, Mastoid portion. 3, Petrous portion. 4, Zygomatic portion. 5, Articulating surface for lower jaw. 6, Temporal ridge. 7, Glenoid fissure. 8, Mastoid foramen. 9, Canal for ear. 10, Groove for digastric muscle. 11, Styloid process. 12, Vaginal process. 13, Glenoid Foramen. 14, Groove for Eustachian tube.

FIG. 47.



Left Parietal Bone. 1, 2, 3, 4, Superior, Inferior, Anterior, and Posterior surfaces. 5, Ridge for Temporal Fascia. 6, Parietal Foramen. 7 and 8, Inferior angles.

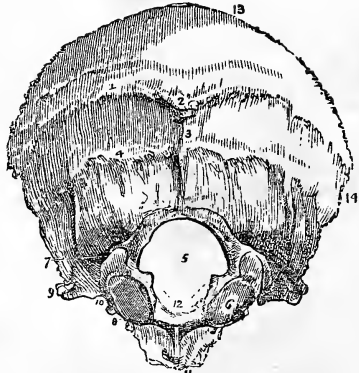
of hearing. Directly behind the external ear is felt a hard projection which is the mastoid process of this bone, and serves for the attachment of many muscles, which move the head. And directly in front of the ear is another prominent process, called the zygomatic, which articulates with the malar bone, and to which is attached one of the elevator muscles of the jaw. The two Parietal Bones are eminently flat bones of a square shape, forming the essential parts of the projections on the back sides of the head, and uniting with each other on the median line, upon the top of the skull. They join with the frontal bone in front, the temporal bones below, and the occipital bone behind. The Occipital

Bone has an imperfectly circular outline, and at its lower

What is the mastoid process? Where is the zygomatic process? Give the form of the Parietals. What is the outline of the Occipital Bone? What is the large orifice in its lower part for? Give the position and general outline of the Sphenoid Bone. With what bones does this articulate?

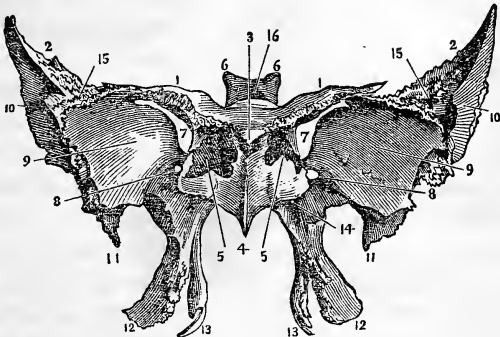
edge a large orifice for the passage of the spinal marrow, just as it enters the vertebræ. It is in the most posterior part of the skull, joining with the sphenoid in front, and resting upon the Atlas vertebra. The Sphenoid Bone is directly underneath the skull, extending from side to side, forming a very small portion of the outside of the skull at the point where the frontal and temporal bones come the nearest to each other. From its name we learn that it is somewhat wedge-

FIG. 48.



External surface of Occipital Bone. 1 and 4, Semicircular Ridges. 2, Occipital Protuberance. 3, Attachment of ligamentum nucleæ. 5, Foramen for Medulla oblongata. 6, Condyle of right side. 7 and 8, Condylloid Foramina. 9, Jugular Eminence. 10, Jugular Foramen. 11, Basilar process. 12, Points of attachment for odontoid ligaments. 13, Edge for attachment with Parietal bone. 14, Point of attachment for Temporal bone.

FIG. 49.

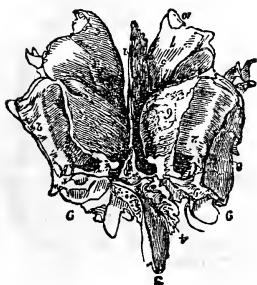


The Anterior and Inferior Surface of the Sphenoid Bone. 1, 1, Apophyses of Ingrassias. 2, 2, The great Wings. 3, Ethmoidal Spine. 4, Azygos Process. 5, Sphenoidal Cells, after the removal of the Pyramids of Wistar. 6, Posterior Clinoid Processes. 7, Sphenoidal Fissure. 8, Foramen Rotundum. 9, Depression for the Middle Lobes of the Cerebrum. 10, Surface for the Temporal Muscle. 11, Styloid Process. 12, External Pterygoid Process. 13, Internal Pterygoid Process. 14, Pterygoid Foramen. 15, Articular Face for the Os Frontis. 16, Points to the Sella Turcica.

shaped in its general outline, although it is covered and filled with cavities and processes for the protection and proper direction of many of the delicate organs which pass through it to their destination. This bone articulates with all those in the cranium, and five of those in the face, and serves as a point of attachment for twelve pairs of muscles, and is one of the most complicated bones belonging to the human skeleton.

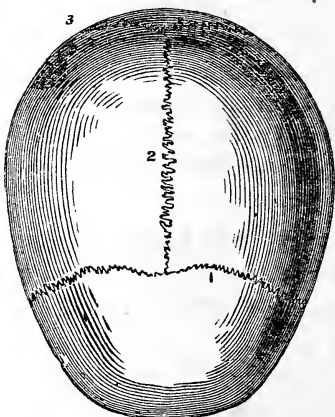
The last bone of the skull is situated at the base of

FIG. 50.



An Upper and Posterior View of the Ethmoid Bone. 1, Nasal Lamella. 2, Body or Cellular Portion. 3, Crista Galli. 4, Cribriform Plate. 5, Superior Meatus. 6, Superior Turbinate Bone. 7, Middle Turbinate Bone. 8, Os Planum. 9, Surface for the Olfactory Nerve.

FIG. 51.



A View of the Outside of the Vault of the Cranium, showing the Sutures. 1, The Coronal Suture. 2, The Sagittal Suture. 3, The Lambdoidal Suture.

the front portion of the cranium, between the sockets of the eyes, and behind the root of the nose. It is called the Ethmoid Bone. Its outline is that of a cube, consisting of a perpendicular plate, and two lateral portions. From the fact that it is extremely fragile, owing to the great number of perforations which it contains, it derives its name from the Greek word signifying a sieve. It is so deeply seated that it receives the attachments of no muscles.

108. Sutures.—The bones of the skull are united by

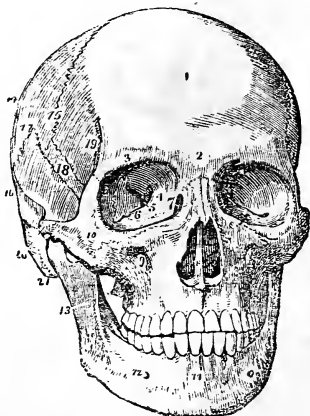
Give the shape and position of the Ethmoid bone. Why called Ethmoid?

ragged edges called Sutures. These are small and rough projections of bone which are largest at their extremities. They are made to fit into the edges of the opposite bone with great firmness, thus joining the bones together, by essentially the same process which in cabinet work is known as dovetailing. The name Suture is applied, since when these edges are perfectly joined by this articulation, they resemble the seam made by sewing together two pieces of cloth by the "over and over" stitch. Situated directly within these sutures are frequently found small bones, uncertain as to number, sometimes two inches in diameter, called Ossa Triquetra. No special use for them has been discovered as yet.

109. The Lower Surface of the Skull.—The whole of the lower surface of the skull is extremely uneven for the attachment of a great number of muscles, and the protection of delicate nerves and blood-vessels which pass to and from the brain and face.

110. Bones in the Face.—The *Face* is that portion of the head situated below a line drawn from the orbit of the eye to the passage of the internal ear. Its framework contains fourteen bones. 2 Nasal ;

FIG. 52.



A Front View of the Skull, showing the Bones composing the Face. 1, Os Frontis. 2, Nasal Tuberosity. 3, Supra-Orbital Ridge. 4, Optic Foramen. 5, Sphenoidal Fissure. 6, Spheno-Maxillary Fissure. 7, Lachrymal Fossa, and commencement of the Nasal Duct. 8, Opening of the Anterior Nares, and the Vomer. 9, Infra-Orbital Foramen. 10, Malar Bone. 11, Symphysis of the Lower Jaw. 12, Anterior Mental Foramen. 13, Ramus of the lower Jawbone. 14, Parietal Bone. 15, Coronal Suture. 16, Temporal Bone. 17, Squamous Suture. 18, Great Wing of the Sphenoid. 19, Commencement of the Temporal Ridge. 20, Zygomatic Process. 21, Mastoid Process.

How do the bones of the skull join with each other? What process in cabinet making does it correspond to? What are often found in these sutures? 109. What is the surface of the lower part of the skull? 110. Give the boundaries of the face.

2 Malar; 2 Lachrymal; 2 Superior Maxillary; 2 Palate: 2 Turbinated; 1 Inferior Maxillary; 1 Vomer.

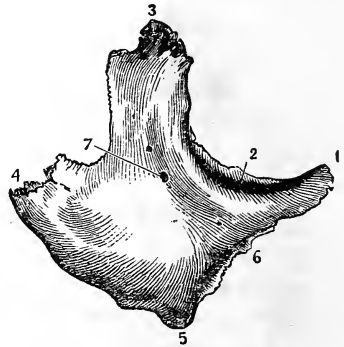
111. Nasal Bones.—The Nasal Bones are oblong, foursided bones, about an inch in length, which together form the bridge or base of the nose.

FIG. 53.



An Anterior and Posterior View of the Nasal Bones. *Right Hand Figure.* 1, Anterior Inferior Extremity. 2, Articulating Surface for its Fellow. 3, Surface for the Nasal Process of the Superior Maxillary Bone. 4, Points to the Groove on the Inner Side, for the Nasal Nerve. 5, Articular Face for the Os Frontis. 6, Foramen for the Nutritious Artery.—*Left Hand Figure.* 1, Posterior Inferior Extremity. 2, Surface for its Fellow. 3, Surface for the Superior Maxilla. 4, Groove for the Internal Nasal Nerve. 5, Surface for the Os Frontis. 6, Lower portion of the Groove for the Nasal Nerve.

FIG. 54.



An Anterior View of the Malar Bone of the Right Side. 1, Anterior Orbital Angle. 2, Orbital Face. 3, Superior Angle for articulating with the Os Frontis. 4, External Angle for the Zygoma of the Temporal Bone. 5 and 6, Inferior Angle and Surface for the Superior Maxilla. 7, Nutritious Foramen.

112. Malar Bones.—The Malar Bones give the prominence and form to the cheek. They are partially hollow, of an irregularly quadrangular outline, and articulate with the frontal above, the zygomatic process of the temporal behind, and the superior maxillary below. The name is from the Latin *Mala*, a “cheek,” hence cheek bones.

113. Lachrymal Bones.—The Lachrymal Bones are the

How many bones in the Face, and what are their names? 111. Describe the Nasal Bones. 112. What bones are found in the cheeks?

smallest bones in the Face, being about $\frac{3}{4}$ th of an inch in diameter. They are situated at the inner angle of the eye, and are named from the Latin *Lachryma*, a "tear," since the tears pass into the nostrils through a canal in these bones. This bone is also called *Os Unguis*.

FIG. 55.



An Anterior View of the *Os Unguis* of the Left Side. 1, Its Anterior Inferior Angle. 2, Orbital Plate and Side for the *Os Planum*. 3, Fossa for the Lachrymal Sac. 4, Superior Extremity.

FIG. 56.



A Posterior and Half Lateral View of the Palate Bone. 1, Palate Plate on its Nasal Surface. 2, Nasal Plate. 3, Pterygoid Process. 4, Surface for Articulating with its fellow. 5, Half of the Crescentic Edge and Spine for the *Azygos Uvulae* Muscle. 6, Ridge for the Inferior Spongy Bone. 7, Spheno-Palatine Foramen. 8, Orbital Plate. 9, Pterygoid Apophysis. 10, Depression for the External Pterygoid Process of the Sphenoid Bone. 11, Same for the Internal Pterygoid Process.

114. **Palate Bones.**—The Palate Bones are the most irregular bones of the face, and when viewed in one direction resemble the capital letter L. They form a part of the orbit of the eye, the wall of the nose, and a large part of the roof of the mouth which is known as the hard palate.

FIG. 57.



115. **Turbinal Bones.**—The Turbinal Bones (really the Inferior Turbinated Bones, since corresponding plates upon the ethmoid bone are called Superior Turbinated

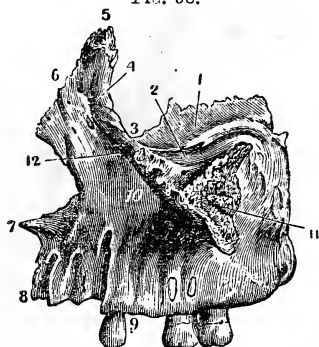
An External View of the Inferior Spongy Bone of the Right Side. 1, Anterior Extremity, for resting on the Ridge of the Upper Maxilla. 2, Posterior, for resting on the Ridge of the Palate Bone. 3, Hooked portion, for resting on the Lower Margin of the Antrum Highmorianum. 4, Its Inferior Border.

113. What are the smallest bones of the face, and why called Lachrymal? 114. What are the most irregularly-shaped bones in the face, and what portion of the mouth is made up by the Palate Bones? 115. Give the description of the Turbinal Bones.

Bones) are curved laminæ or thin plates of bone, resembling a loose scroll, and are found in each nostril, for the purpose of affording as large a surface as possible for the expansion of the mucous membrane of the nose, which contains the nerves of smell. The name Turbinal or Turbinated is applied because of their scroll-like appearance.

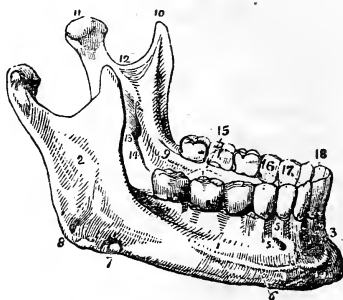
116. Superior Maxillary Bone.—The Superior Maxillaries are the largest bones of the face, joining with each other

FIG. 58.



An External View of the Superior Maxilla of the Left Side. 1, Orbital Process. 2, Infra-Orbital Canal. 3, Space for the Os Unguis. 4, Upper part of the Lachrymal Canal. 5, Nasal Process, and Surface for Articulating with the Os Frontis. 6, Surface for the Nasal Bone. 7, Anterior portion of the Floor of the Nostril. 8, Surface for Articulating with its Fellow. 9, Alveolar Process. 10, Points to the Depression just below the Infra-Orbital Foramen. 11, Surface for the Malar Bone.

FIG. 59.



The Inferior Maxillary Bone. 1, The Body. 2, The Ramus. 3, The Symphysis. 4, Alveolar Process. 5, Anterior Mental Foramen. 6, The Base. 7, Groove for the Facial Artery. 8, The Angle. 9, Extremity of the Ridge for the Mylo-Hyoid Muscle. 10, Coronoid Process. 11, Condyle. 12, Neck of the Condyloid Process. 13, Posterior Mental Foramen. 14, Groove for the Inferior Maxillary Nerve. 15, Molar Teeth. 16, Bicuspidate Teeth. 17, 18, Middle and Lateral Incisors.

on the median line, and thus form a portion of the roof of the mouth. Each one of them articulates with eight teeth, with all the bones of the face but the lower jaw, and two of the cranium. Their name is from the Latin, *Maxilla*, a "jaw," and both of them constitute the upper jaw.

117. Mandible.—The Inferior Maxillary, or lower jaw, is

116. How are the Superior Maxillaries situated? How many teeth are found in each of them? 117. Describe the Mandible.

the only movable bone of the head or face. It contains the sixteen lower teeth, is of an arched form, and at each extremity has a square-shaped process for articulation with the temporal bones, and the attachment of muscles.

118. *Vomer*.—The name of the *Vomer* is derived from the Latin meaning a “plow-share,” on account of its approximate resemblance to that object. It completely separates the nostrils from each other, and like the turbinated bones gives attachment to no muscles.

FIG. 60.



The *Vomer*. 1, 2, Posterior and Superior Surface hollowed to receive the Azygos Process of the Sphenoid Bone. 3, Anterior Surface for the Cartilaginous Septum of the Nose.

119. *Number of Teeth*.—The Teeth of the Human Adult when all present in the jaws, number thirty-two. And although properly bones, still they differ in three respects:

1st, Organic Composition.

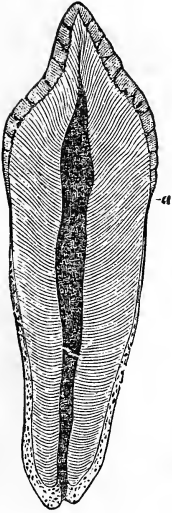
2nd, Time of Development and Replacement.

3d, Decay when fractured.

120. *Organic Composition, Cementum, Dentine, Enamel, Microscopic Structure of Enamel, Development of Teeth, Nasmyth's Membrane*.—The Teeth are composed of three substances: a *Cementum* which forms a thin coating on the fangs of the teeth, and which thickens in advanced life; the *Dentine* which resembles bone in its external characteristics and makes the largest part of the teeth, containing the principal vessels and nerves of the teeth; and the *Enamel*, the hardest substance in the human body, which is a covering to

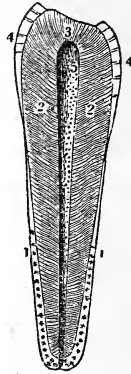
118. From what does the *Vomer* derive its name? What two cavities does it separate? 119. How many teeth in an adult? In what respects do they differ from the other bones of the body? 120. Of what substances are the teeth composed?

FIG. 61.



Vertical Section of Human Incisor. *a*, the point where the Gum is attached to the Tooth.

FIG. 62.

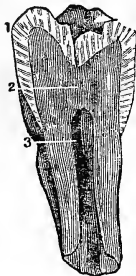


A Vertical Section of an Adult Bicuspid, cut from without inwards; magnified four times. 1, 1, The Cementum which surrounds the Root up to the commencement of the Enamel. 2, 2, The Dentine of the Tooth, in which are seen the greater Parallel Curvatures, as well as the position of the Main Tubes. 3, Apex of the Tooth, where the Tubes are almost perpendicular. 4, 4, The Enamel. 5, The Cavity of the Pulp, in which are seen, by means of the Glass, the Openings of the Tubes of the Dental Bone.

FIG. 63.



FIG. 64.



A View of an Incisor and of a Molar Tooth, given by a Longitudinal Section, and showing that the Enamel is striated and that the Striæ are all turned to the center. The Internal Structure is also seen. 1, The Enamel. 2, The Ivory. 3, The Cavitas Pulpæ.

all the tooth above the gums. This is a pure white substance, thickest upon the top of the crown, and gradually growing thinner towards the gum, where it disappears altogether. Under the microscope it is seen to be made up of minute hexagonal fibers, one end of which rests upon the Dentine, and the other forms the free surface of the tooth. These tubes or fibres are slightly undulating and

from $\frac{1}{8000}$ th to $\frac{4}{54000}$ d of an inch in diameter. The enamel is also covered by a very thin membrane, $\frac{1}{15000}$ st of an inch in diameter, called Nasmyth's membrane. This is a "calcified" membrane and can be seen only with great care, since it is not acted upon by the strongest acids or alkalis.

121. Development of Teeth. Temporary Set. Permanent

Set.—The teeth in the human subject are not perfectly formed at birth, but exist in the form of follicles or shut sacs, which at the seventh or eighth month of infantile life, are developed into teeth. The process of dentition generally occupies from one to three years, during which time the temporary set, as it is termed, make their appearance. These number twenty, ten in each jaw, and between the age of seven and fourteen become loose, and are easily removed to give place to the permanent set which numbers thirty-two. Generally, however, the last tooth in each jaw does not make its appearance until the twentieth year of life.

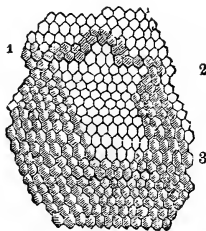
122. A more accurate statement of dentition of the temporary teeth shows that they *appear* at the following ages :

The Incisors,	from the 7th to the 10th month.
The Anterior Molars,	12th " 13th "
The Canine Teeth,	14th " 20th "
Posterior Molars,	18th " 36th "

123. The permanent teeth appear as follows :

Describe each of the teeth. What membrane completely covers the outside of the tooth? 121. Illustrate the development of the teeth. 122. Give the time of appearance of the temporary teeth. 123. When do the permanent teeth appear?

FIG. 65.



A portion of the Surface of the Enamel on which the Hexagonal Terminations of the Fibres are shown; highly magnified. 1 2, 3, Are more strongly marked dark, crooked Crevices, running between the rows of the Hexagonal Fibres.

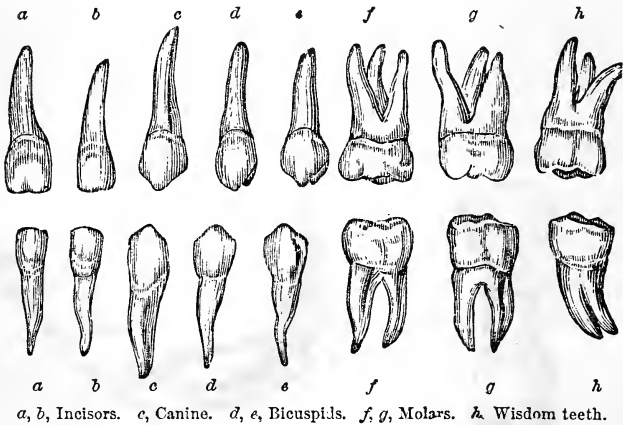
Incisors, from the 8th to the 9th year.			
Bicuspid,	10th	"	11th
Canines,	12th	"	12½th
Second Molars,	12½th	"	14th
Third Molars,	17th	"	19th

124. Names of Teeth.—A third set of teeth has been known to make its appearance; also a tooth extracted and at once replaced may become firm again at the end of some months.

The names and number of the permanent teeth in each jaw, beginning at the posterior part of the mouth, are :

2 Wisdom, 4 Molars, 4 Bicuspid, 2 Canine, 4 Incisors.

FIG. 66.



125. Fracture of Teeth.—All the bones of the body, except the teeth, when broken will become united again; but if the teeth lose a portion of their enamel, or even if it be cracked, the tooth so injured at once begins to decay, and will be entirely consumed, unless the disease be checked by artificial means.

124. What is said about a third set? Give the names of the permanent teeth.
 125. What if the teeth are broken or cracked?

126. Hyoid Bone.—The Hyoid Bone is the bone which forms the base of the tongue, and the upper extremity of the trachea. It has the shape of the Greek letter *U* (or Upsilon) and articulates with no other bones, but is completely enveloped by the soft parts. It has a considerable range of motion in a vertical direction, and hence gives attachment to no less than eleven pairs of muscles.

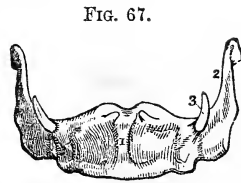


FIG. 67.
An Anterior View of the Os Hyoides. 1, The Anterior Convex Side of the Body. 2, The Cornu Majus of the Left Side. 3, The Cornu Minus of the same Side. The Cornua were ossified to the Body of the Bone, in this specimen.

127. Sternum.—The Breast Bone is flat, about eight inches in length, one and a half in width, and is located on the median line of the body upon the front portion of the thorax or chest, articulating with the seven upper ribs on both sides, and also with the clavicle.

128. Ribs.—There are twenty-four ribs in the human



FIG. 68. A Front View of the Sternum. 1, First Piece. 2, Second Piece. 3, Ensiform Cartilage, or Third Piece. 4, Articular Face for the Clavicle. 5, Articular Face for the First Rib. 6, Articular Face for the Second Rib. 7, 8, 9, 10, Articular Faces for the Last Five True Ribs.

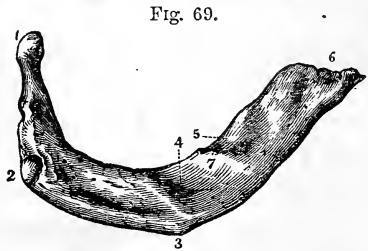


FIG. 69. A View of the Upper Side of the First Rib of the Right Side, half the size of nature. 1, The Head. 2, The Tubercle. 3, Anterior Surface. 4, Groove for the Subclavian Artery. 5, Groove for the Subclavian Vein. 6, Anterior Extremity for the Cartilage. 7, Tubercle for the Scalenus Anticus Muscle.

126. Where is the Hyoid Bone? What Greek letter does it resemble? 127. Describe the Sternum. With what bones does it articulate? 128. Number of Ribs in man?

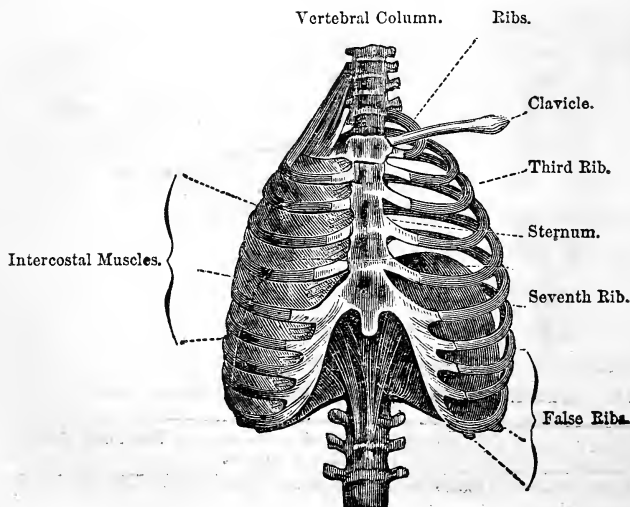
FIG. 70.



General Character of the other Ribs, seen on their Upper and Under Surface. *The left hand figure is the Upper Face of the Rib.* 1, Head of the Rib. 2, Its Tubercle. 3, Anterior Extremity for the attachment of the Costal Cartilage. 4, Groove for the Artery and Nerve. 5, Angle of the Rib. *The right hand figure is the Under Surface of the Rib.* 1, The Head. 2, Its Tubercle. 3, Anterior Extremity. 4, Groove for Intercostal Artery and Nerve. 5, Angle of the Rib.

body, which are divided into two classes, the true and the false, or those which are closely united with the sternum, and those which are remotely attached to it by long cartilages. They are attached at their posterior extremities to the vertebræ, and run downwards and forwards, so that when elevated,

FIG. 71.



they enlarge the cavity of the chest. The true ribs are the seven uppermost ones, and the false the five lower ones, and are so arranged that they form a cone with the apex at the neck. The two lowest ribs are sometimes called "floating," because they are only attached to the vertebræ.

129. Clavicle.—

The Collar Bone is the commencement of the upper extremity. It is one of the class of long bones extending from the highest point of the scapula to the upper part of the sternum, and bears a partial resemblance to the Italic letter F. The name is from the Latin *Clavis*, "a key," since it remotely resembles an antique key.

FIG. 72.



An Anterior View of the Clavicle of the Right Side. 1, The Anterior Face of the Body of the Bone. 2, Origin of the Clavicular portion of the Sternocleido-Mastoid Muscle. 3, The Sternal Extremity of the Bone. 4, The Acromial Extremity of the Bone. 5, Articular Face for the Acromion Process of the Scapula. 6, Point of Attachment of the Conoid Ligament. 7, Point of Attachment of the Rhomboid Ligament.

130. Scapula.—A large, flat, and triangular bone upon the upper part of the back, and forming the shoulder, is called the Scapula, or Shoulder Blade. It has a high and narrow ridge running through its longest diameter, which is the bone so distinctly felt upon the shoulder and upper part of the back. Its only articulations are with the clavicle and humerus, the posterior part being kept in its place by muscles and ligaments. (Fig. 73, p. 58).

131. Humerus.—The Humerus is the bone of the upper arm or shoulder. (Fig. 74, p. 58.) It is a long bone with a cylindrical shaft, and has a rounded head for its upper extremity. The lower extremity is flattened from before back-

What two classes are they divided into? What do they all unite with behind? 129. What two bones does the Clavicle unite with? 130. What is the general outline of the Scapula? Where is it located? What are its only articulations? 131. What is the bone of the upper arm?

FIG. 73.



A Posterior View of the Scapula of the Left Side. 1, Fossa Supra-Spinata. 2, Fossa Infra-Spinata. 3, Superior Margin. 4, Coracoid Notch. 5, Inferior Margin. 6, Glenoid Cavity. 7, Inferior Angle. 8, The Neck and Point of Origin of the Long Head of the Triceps Muscle. 9, Posterior, or Vertebral Margin. 10, The Spine. 11, Smooth Facet for the Trapezius Muscle. 12, Acromion Process. 13, Nutritious Foramen. 14, Coracoid Process. 15, Part of the Origin of the Deltoid Muscle.

16, Part of the Origin of the Deltoid Muscle. 17, External Bicipital Ridge. 9, Point of insertion of the Deltoid Muscle. 10, Nutritious Foramen. 11, Articular Face for the Head of the Radius. 12, Articular Face for the Ulna. 13, External Condyle. 14, Internal Condyle. 15, 16, The Condylloid Ridges. 17, Lesser Sigmoid Cavity.

FIG. 74.



An Anterior View of the Humerus of the Right Side. 1, The Shaft, or Diaphysis of the Bone. 2, The Head. 3, Anatomical Neck. 4, Greater Tuberosity. 5, Lesser Tuberosity. 6, The Bicipital Groove. 7, External Bicipital Ridge for the insertion of the Pectoralis Major. 8, Internal Bicipital Ridge. 9, Point of insertion of the Deltoid Muscle. 10, Nutritious Foramen.

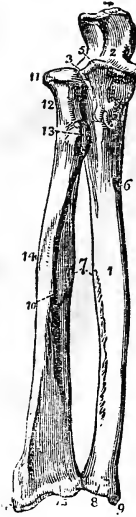
wards, and so formed into grooves and elevations that it articulates with the ulna in essentially the same manner as the two portions of a door hinge.

132. Fore-arm. The Ulna.—There are two bones in the forearm, one of which only is articulated with the humerus, and the other to the bones of the wrist alone, in order to allow the rotation of the hand upon the bones of the forearm,

What is the shape of the lower, or ulnar articulation? 132. How many bones in the forearm? Why are there two instead of one?

as if they constituted a pivot; an instance of which is seen in the turning of a screw, or in the unlocking of a door. Of these two bones the Ulna articulates with the humerus, forming only a ligamentous union with the bones of the wrist. It is prismoid in form, and is of a hooked shape at its upper extremity, so that it makes the union between itself and the humerus a very secure one. The word ulna is a Latin term signifying an ell, because the forearm in early times was used for that measure.

FIG. 75.



Bones of the Forearm. 1, The Ulna. 2 and 3, The Sigmoid Notches. 4, The Olecranon Process. 5, Coronoid Process. 6, Nutritional Foramen. 7, Ridge for attachment of Interosseous Membrane. 8, Capitulum Ulnæ. 9, Styloid Process. 10, Shaft of the Radius. 11, 12 and 13, Head, Neck, and Tuberosity of Radius. 14, Oblique Line for muscular attachments. 15, Styloid Process.

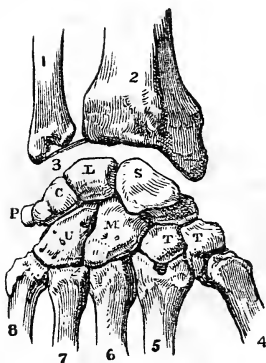
133. The Radius.—The Radius is the mate of the ulna. Its upper extremity is the smallest, and the lower the largest, since its only true articulation is at the wrist. A firm membrane, however,

unites this bone to its fellow nearly its whole length. It probably derives its name from the fact that it measures the radius of a circle which may be described by the hand about the elbow as a center.

134. The Carpus.—The bones of the Carpus or Wrist are eight in number, are small and irregular, and have the general disposition of two rows. The first row, commencing with the one nearest the thumb, contains the Scaphoid, Semilunar,

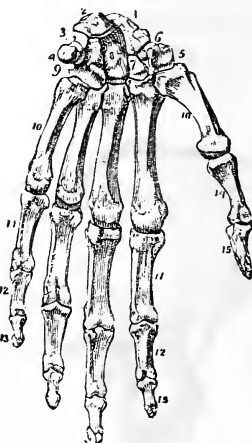
In what operations do we need the two bones of the forearm? Give the derivation of ulna. 133. What is the mate of the ulna? Where does this articulate? What is the derivation of its name? 134. How many bones in the wrist? Give their names.

Fig. 76.



A Posterior View of the Articulations of the Bones of the Carpus in the Right Hand. 1, The Ulna. 2, The Radius. 3, Inter-Articular Fibro-Cartilage. 4, Metacarpal Bone of the Thumb. 5, Metacarpal Bone of the Second Finger. 6, Metacarpal Bone of the Third Finger. 7, Metacarpal Bone of the Fourth Finger. 8, Metacarpal Bone of the Fourth Finger. S, The Scaphoides. L, The Lunare. C, The Cuneiforme. P, The Pisiforme. T, T, Trapezium and Trapezoides. M, The Magnum. U, The Unciforme.

FIG. 77.



An Anterior View of the Left Hand. 1, The Scaphoides. 2, The Lunare. 3, The Cuneiforme. 4, The Pisiforme. 5, The Trapezium. 6, Groove for the Flexor Carpi Radialis Tendon. 7, The Trapezoides. 8, The Magnum. 9, The Unciforme. 10, 10, The Five Meta-Carpal Bones. 11, 11, First Row of Phalanges. 12, 12, Second Row of Phalanges. 13, 13, Third Row of Phalanges. 14, First Phalanx of the Thumb. 15, Last Phalanx of the Thumb.

Cuneiform, and Pisiform. The second in the same order, the Trapezium, Trapezoid, Magnum, and Unciform.

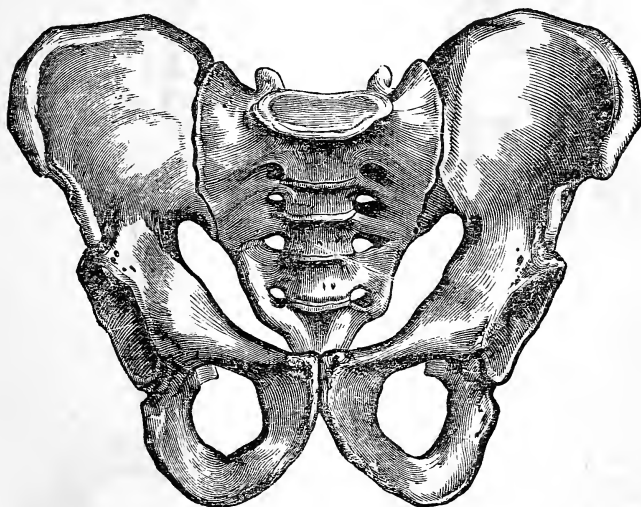
135. The Metacarpus.—The Metacarpus contains five bones. Each of these articulate with the carpus above, and the phalanges below, being found in the space known as the palm or body of the hand.

136. The Phalanges.—The Phalanges are the bones of the thumb and fingers, two in the former, and three in the latter, making fourteen in each hand.

135. Describe the Metacarpal Bones. What part of the hand do they occupy?
136. How many Phalanges in the thumb, and how many in each finger? What is the whole number of them?

137. **Bones of the Pelvis.**—The bones of the Pelvis are the two Innominata or nameless bones, and the Sacrum and Coccyx, which have already been described. (Fig. 78.)

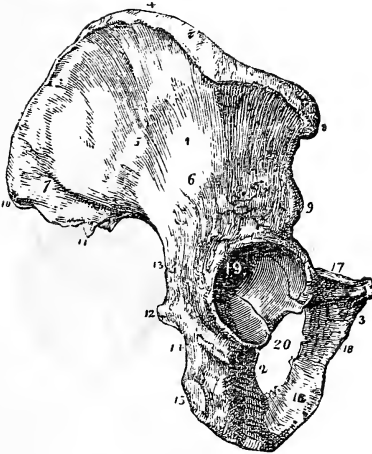
FIG. 73.



138. **The Innominatum, Ilium, Ischium, Pubes.**—Each Innominatum presents the largest surface of any bone in the body. They are irregularly flat bones and situated just beneath the abdomen, to the organs of which they give firm support by their broadly-expanded surface. In young skeletons they are divided into three portions, and hence they are described in the adult as made up of three parts, although no line of division can actually be seen. The Ilium constitutes the broadly-expanded portion usually known as the hip or haunch. The Ischium, from the Greek signifying to “hold” or “retain,” is the heavy portion projecting downwards, and that point on which the body rests, when in a sitting posture.

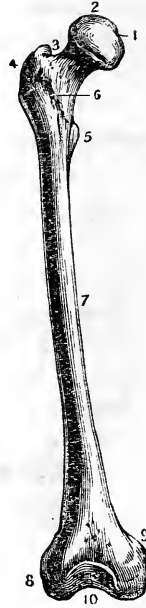
137. How many bones in the Pelvis, and what are their names? 138. Describe the Innominatum. Into how many parts are they divided in young animals? Describe the Ilium and the Ischium.

FIG. 79.



Outside of the Innominate of the Right Side. 1, Dorsum of the Ilium. 2, Ischium. 3, Pubis. 4, Crest of the Ilium. 5, Surface of the Gluteus Medius. 6, Surface for the Gluteus Minimus. 7, Surface for the Gluteus Maximus. 8, Anterior Superior Spinous Process. 9, Anterior Inferior Spinous Process. 10, Posterior Superior Spinous Process. 11, Posterior Inferior Spinous Process. 12, Spine of the Ischium. 13, Greater Sacro-Sciatic Notch. 14, Lesser Sacro-Sciatic Notch. 15, Tuber Ischii. 16, Ascending Ramus of the Ischium. 17, Body of the Pubis. 18, Ramus of the Pubis. 19, Acetabulum. 20, Thyroid Foramen.

FIG. 80.



An Anterior View of the Femur of the Right Side. 1, Depression for the Round Ligament. 2, The Head. 3, The Neck. 4, Trochanter Major. 5, Trochanter Minor. 6, Surface for the Capsular Ligament. 7, Shaft of the Bone. 8, The External Condyle. 9, The Internal Condyle. 10, Surface for the Patella.

The Pubis is the most central and anterior portion. These three divisions unite at the point known as the acetabulum or receptacle for the head of the femur, which is a perfect hemispherical cup lined with cartilage.

139. The Femur.—The Femur is nearly two feet in length, and consequently the longest bone in the body, commonly known as the Thigh Bone. At its upper portion it makes a

139. What is the average length of the Femur? Give its general features. What is the longest bone in the body?

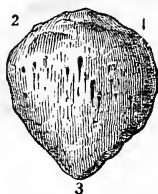
sudden bend inwards, forming the neck of the bone, the termination of which is hemispherical, in order to articulate with the innominatum, forming the ball and socket joint. Its lower extremity has two large condyles or processes, for the purpose of giving attachments to the ligaments of the knee, and articulating with the tibia.

140. The Patella —Or Knee Pan is the largest sesamoid bone in the body. It articulates with the femur, and lies imbedded in the extensor tendon of the thigh. The chief value of this bone is to give a change of direction to the force of the muscles which move the lower bones of this extremity we are now describing. Patella in Latin signifies a "plate," and hence the name of this bone, because of its rounded outline.

141. The Tibia.—That portion of the lower extremity below the knee, which is properly the leg, has two bones called crural for its framework. The largest of these is the Tibia (Fig. 82, p. 64.) It is somewhat triangular in its general outline, having its upper extremity depressed in two places for the reception of the condyles of the femur. Besides the femur above, it articulates with the fibula and astragalus below. The name tibia is given to the bone, since it resembles, though remotely, the ancient Phrygian flute.

142. The Fibula.—The Fibula is the other bone of the leg, long and slender. It articulates at each end with the tibia. The meaning of the Latin *fibula*, is a "pin," or fastening of a clasp, owing to its slender form. The lower extremity of this bone, and also that of the tibia, forms what

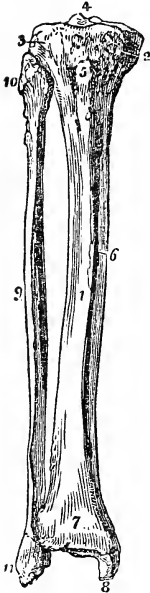
FIG. 81.



An Anterior View of the Patella. 1, 2, Surface for the Quadriceps Femoris Tendon. 3, Lower Extremity and Point of Origin of the Ligamentum Patellae.

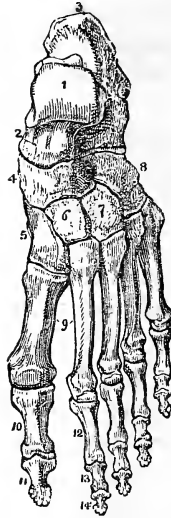
140. Describe the Patella or Knee Pan. In what is it imbedded? 141. What is the Leg? What are the two bones of it? Which is the largest and consequently most important one? 142. Give the general description of the Fibula. What compose the external and internal Malleoli?

FIG. 82.



Right Tibia and Fibula. 1, Tibia. 2 and 3, Inner and Outer Tuberosity. 4, Spinous Process. 5, Tubercle for attachment of Muscles of the Thigh. 6, Edge of Tibia. 8, Internal Ancle. 9, The Fibula. 10 and 11, Extremities of Fibula.

FIG. 83.



A View of the Upper Surface of the Left Foot. 1, The Astragalus on its Upper Face. 2, Its Anterior Face, Articulating with the Naviculare. 3, The Os Calcis. 4, Naviculare, or Scaphoides. 5, The Internal Cuneiform. 6, The Middle Cuneiform. 7, The External Cuneiform. 8, The Cuboid Bone. 9, 9, Metatarsal Bones. 10, First Phalanx of the Big Toe. 11, Second Phalanx of the Big Toe. 12, 12, 13, 13, 14, 14, The First, Second and Third Phalanges of the other Toes.

are known as the external and internal malleolus, or the two long projections on each side of the ancle.

143. The Tarsus.—The Tarsus is made up of seven irregular bones, forming the instep of the foot. The Astragalus is of a cubical form (so named from its resemblance to the die, used in games of chance) and supports the tibia alone. The Os Calcis, meaning the bone of the heel, is the largest of the bones of the tarsus, and is irregularly cubical

143. How many bones make up the Tarsus? Why is the uppermost called the Astragalus? Which is the largest of these bones?

in form, making, by a decided projection, the heel. Directly beneath and anterior to the last two, are found the Cuboid (cube-shaped) and the Scaphoid (boat-shaped), and anterior to these the three Cuneiform (wedge-shaped), articulating with the metatarsal bones in front.

144. Metatarsal Bones.—These are five in number, and correspond with those in the metacarpus, except that the one in the first toe is of equal length with the others, and does not admit of so free motion as that of the thumb.

145. The Phalanges.—The Phalanges of the foot are also like those of the hand, except that in the foot the first row is the longest, while in the hand it is in the third row or second finger.

146. Sesamoid Bones.—Besides the bones already mentioned, there are frequently found in stout adult men small bones, or portions of bony matter called Sesamoid Bones, from their resemblance to the Sesamum, a kind of bean. And although they are not constant either in individuals, or in the same places in the individual, yet anatomists are accustomed to reckon eight, or four pairs as the normal number. They are all found enclosed in tendons, and serve like the patella to change the direction of motion. They are found at the point where the tendon glides over the joint made by the phalanges and metatarsus of the foot, and the metacarpus of the hand, in the tendon which plays over the under surface of the cuboid bone in the foot; and also in the tendons that glide over the lower condyles of the femur.

147. Bones of the Ear.—In the Ear are three bones which will be more appropriately described with the organ itself.

148. Number of Bones. Single Bones.—Of the 246

144. How many Metatarsal Bones? 145. How many Phalanges of the Foot? How do they differ from those of the hand? 146. Describe Sesamoid Bones. How many are there, and where are they generally found? 147. How many bones of the Ear?

bones found in the human body, all but thirty-four are found in pairs, or one upon each side of the body. The single bones are the frontal, occipital, ethmoid, sphenoid, vomer, mandible, hyoid, sternum, twenty-four vertebræ, the sacrum and the coccyx.

SYNDESMOLOGY.

DESCRIPTION OF THE LIGAMENTS.

149. *Kinds of Articulation.*—The modes or manner of connection between the different bones of the body are three: *Synarthrosis*, *Amphiarthrosis*, and *Diarthrosis*. The first of these modes, means the joining of such bones as have no motion between them; the second, a joint with the aptitude for movement between the immovable *synarthrosis* on the one hand, and the movable *diarthrosis* on the other; the third, a movable articulation, which constitutes by far the greater part of the joints of the body.

150. *Sutura, Harmonia, Schindylesis, Gomphosis.*—Of *Synarthrosis* there are four varieties: first, *Sutura*, the articulation between the bones of the skull by ragged interlocking edges; second, *Harmonia*, that between the two upper maxillaries, where the bones with comparatively straight edges are simply placed edge to edge; third, *Schindylesis*, or the joint between the vomer and sphenoid, where the expanded edge of one bone is fitted into a corresponding groove in the other; fourth, *Gomphosis*, the articulation of the teeth with the jaws, and so named since it resembles the manner in which a common nail is driven into a plank.

148. How many bones in the human body are found in pairs? Give the names of the unpaired bones. 149. How many modes of connecting the bones together? Describe each. 150. Give the peculiarities of *Sutura*, of *Harmonia*, of *Schindylesis*, and of *Gomphosis*. Give an example of the latter.

151. Symphyses.—Of Amphiarthrosis there is but one kind, the Symphyses, or the apposition of two bones with simply cartilage between. Examples of this are the articulations of the vertebræ, and the ossa pubis.

152. Arthrodia, Ginglymus, Enarthrosis.—Of Diarthrosis there are three varieties: Arthrodia, Ginglymus, and Enarthrosis. Arthrodia is a slightly movable joint, as of the wrist and ancle bones, or the radius and ulna. Ginglymus is the common hinge joint, where the degree of movement is very considerable, but only in two directions. The best example of this is in the knee. Enarthrosis is the ball and socket joint, that admits of movement in all directions. The only cases of this articulation are in the shoulder, hip, and thumb.

153. Anatomy of the Articulations.—In synarthrosis there is simply a membrane interposed between the two bones which keeps them in their places. In amphiarthrosis the two extremities are partly covered with cartilage, lined by synovial membrane, and partly connected by the interosseous ligaments, or by an elastic fibro-cartilage which adheres to both edges of the bones. In diarthrosis especially, as it is exhibited in ginglymus, the general outline of the bone is quadrilateral, upon each edge of which is found a ligament. The lateral ones, however, are the main supports of the joint, while the anterior and posterior ones are thin and a part of the time loose, which are only of service to determine the amount of movement in the joint. An example of this is seen in the fingers, since they can only be extended so as to lie in the axis of the metacarpal bones. The reason why they can not be bent back upon the dorsal surface of the hand is that the anterior ligament does not admit of suffi-

151. Describe the Symphyses. Give an example. 152. Give the three varieties of Diarthrosis. Give an example of Arthrodia, Ginglymus, and Enarthrosis. 153. What are the component parts of the different articulations? Give the mode of articulation of the fingers. Why can not the finger be bent upon the back of the hand?

cient movement in that direction. In the knee, however, there are thirteen ligaments.

154. *Motions of the Joints.*—The motions of the joints may be comprised under four principal divisions: Gliding, Angular movement, Circumduction, and Rotation.

155. *Gliding.*—Gliding movement is where the bones simply slip over one another in the movement of the joint, and exists to a greater or less extent in all the joints.

156. *Angular.*—Angular movement may be performed in four directions: forwards and backwards, called flexion and extension, and inwards and outwards, called adduction and abduction. A joint, as the finger, is said to be flexed when it is bent upon itself, that is upon the palm of the hand, and extended when it is stretched to its fullest extent, or as in the finger, when it is made straight with the bones of the fore-arm. Adduction means the bringing of one of the extremities towards the body, or its fellow, while abduction has the reverse signification.

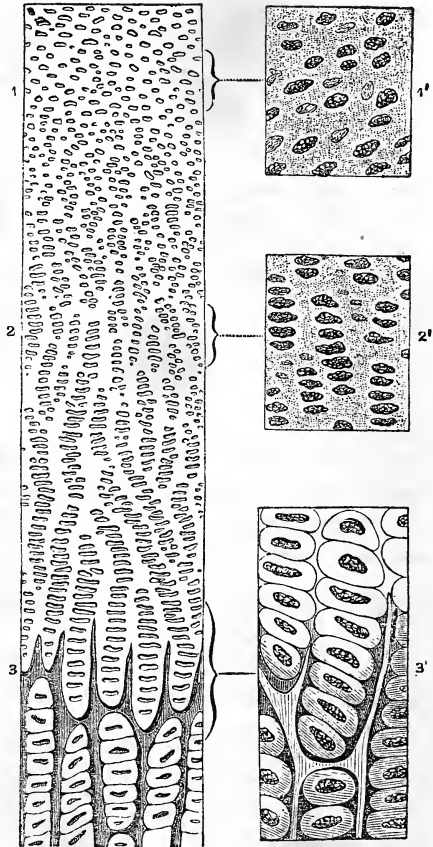
157. *Circumduction.*—Circumduction can be performed only by the ball and socket joints. It consists in carrying the limb about the joint in a circular plane, or in other words, describing a circle about the joint as a center.

158. *Rotation.*—Rotation is the movement of a bone upon its own axis. A slight rotatory movement can be effected in the joints of the shoulder and hip, but the best instance is that of the radius rotating against the articular head of the humerus, producing the subdivisions pronation and supination. Pronation consists in rotating the fore-arm so that the palm of the hand shall be downwards, and Supination the reverse. Rotation is also observed in the movement of the atlas upon the pivot of the axis.

154. What are the four motions of the joints? 155. Describe the Gliding movement.
156. In what four directions can Angular movements be? 157. What is Circumduction?
158. Describe Rotation. What is Pronation and Supination?

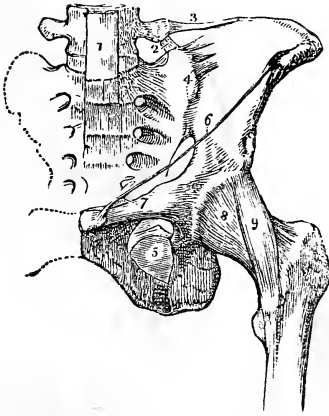
159. Structure of Ligaments. Arrangement of Ligaments. Capsular Ligament. Round Ligament.—The bones are firmly bound together by ligaments. These are for the most part bands of white glistening fibres, as firm as steel, which are composed of white fibrous tissue. They are generally very short, and attached only to the enlarged extremities of the bone. In most of the joints, and especially the ginglymus, the ligaments are arranged in a cross shape upon the sides of the bones, so that one bone may glide freely over the extremity of another, as one half of a door hinge moves upon its other half. In other instances the ligament surrounds the whole

Fig. 84.



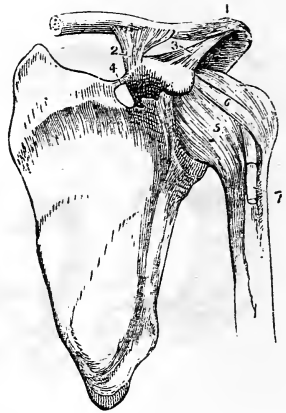
A magnified View of a Vertical section of Cartilage from a new-born Rabbit, showing the progress towards ossification. 1, The Ordinary appearance of Temporary Cartilage. 1', The same, more highly magnified. 2, The Primary Cells beginning to assume the linear direction. 2', The same, more highly magnified. 3, The Ossification is extending in the intercellular spaces, and the rows of cells are seen resting in the cavities so formed, the Nuclei being more separated than above. 3', The same, magnified more highly.

FIG. 85.



An Anterior View of the Ligaments of the Pelvis. 1, The Lower part of the Anterior Vertebral Ligament. 2, The Sacro-Vertebral Ligament. 3, The Ilio-Lumbar Ligament. 4, The Anterior portion of the Sacro-Iliac Ligament. 5, The Obturator Ligament. 6, Poupart's Ligament. 7, That portion of the same which is known as Gimbernat's Ligament. 8, The Capsular Ligament of the Hip-Joint. 9, The Accessory Ligament of the Hip-Joint.

FIG. 86.

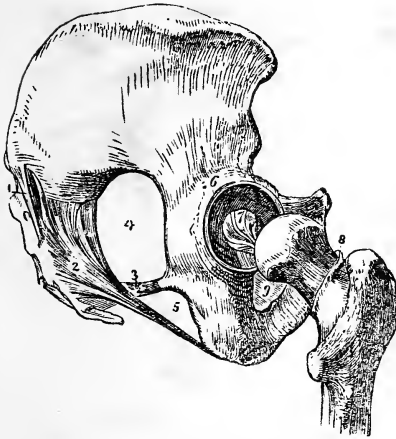


Ligaments from Shoulder-Joint 1, The Superior Acromio-Clavicular Ligament. 2, The Coraco-Clavicular Ligament. 3, The Coraco-Acromial Ligament. 4, The Coracoid Ligament. 5, The Capsular Ligament of the Shoulder-Joint. 6, The Ligamentum Adscititium, or Coraco-Humeral Ligament. 7, The Tendon of the Long Head of the Biceps Muscle, issuing from the Capsular Ligament.

joint, making it a shut sac, thus performing the double office of keeping the two ends in contact, and of holding the lubricating fluid in the joint. In addition to these, there is in the ball and socket joint another kind of ligamentous attachment between the two bones, called the round ligament, or Ligamentum Teres. This is a bundle of ligamentous fibres in the form of a cord, which is inserted into the summit of the rounded head of the bone, and also in the bottom of the cup-shaped cavity that receives the head. This is somewhat lax ordinarily, but not so much so but that it keeps the head from slipping out of its socket, and at the same time allows the most perfect freedom of motion.

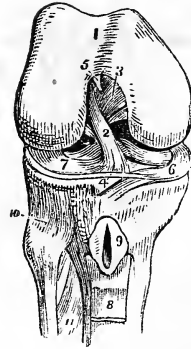
159. What are the Ligaments? To what part of the bones are they generally attached? How are they arranged in Ginglymus joints? Why are they sometimes found in the form of a shut sac? Describe the round ligament.

FIG. 87.



A Lateral View of the Ligaments of the Hip-Joint and Pelvis. 1, The Posterior Sacro-Iliac Ligament of the Pelvis. 2, The greater Sacro-Sciatic Ligament. 3, The Lesser Sacro-Sciatic Ligament. 4, The Greater Sacro-Sciatic Notch. 5, The Lesser Sacro-Sciatic Notch. 6, The Cotyloid Ligament around the Acetabulum. 7, The Ligamentum Teres. 8, The Line of Attachment of the Capsular Ligament of the Hip-Joint, posteriorly. The Ligament has been removed, in order to show the Joint. 9, The Obturator Ligament.

FIG. 88.



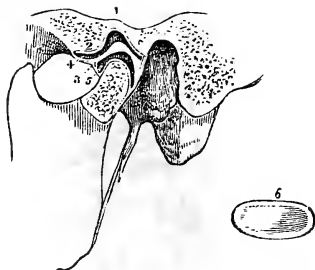
The Right Knee-Joint laid open, 1, The Lower End of the Femur covered by its Articular Cartilage. 2, The Anterior Crucial Ligament. 3, The Posterior Crucial Ligament. 4, The Transverse Fasciculus adhering to the Semilunar Cartilages. 5, The Point of Attachment of the Ligamentum Mucosum, the rest of it has been removed. 6, The Internal Semilunar Cartilage. 7, The External Semilunar Cartilage. 8, A part of the Ligamentum Patellæ turned downwards. 9, Its Bursa laid open. 10, The Superior Peroneo-Tibial Articulation. 11, The Interosseous Ligament.

160. Aid of Atmospheric Pressure.—Atmospheric pressure also helps to keep the bones together. For since the projection of one member so accurately fits the depression in the other, and as the lubricating fluid makes the coupling most perfect, the pressure of the atmosphere assists not a little to keep the parts together.

161. Inter-articular Cartilage.—Another arrangement in the joints is not a little singular, and well adapted to its purpose. This is an interarticular cartilage in the knee called semilunar, or a small disc of cartilage which lies loosely be-

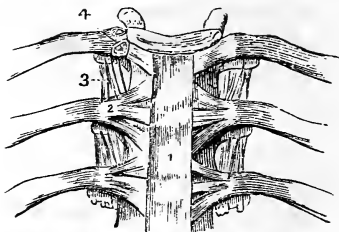
160. What besides the ligaments helps to keep the bones together? 161. Describe the interarticular cartilage and its use.

FIG. 89.



A View of the Articulation of the Lower Jaw, given by sawing through the Joint. 1, The Glenoid Fossa. 2, The Tubercle for the Condyle in its Forward movements. 3, The Inter-Articular Cartilage. 4, The Superior Synovial Cavity. 5, The Inferior Synovial Cavity. 6, The Inter-Articular Cartilage removed from the Joint and seen from below.

FIG. 90.



An Anterior View of the Ligaments of the Vertebrae and Ribs. 1, The Anterior Vertebral Ligament. 2, The Anterior Costo-Vertebral Ligament. 3, The Internal Transverse Ligament. 4, The Inter-Articular Ligament, connecting the Head of the Rib to the Intervertebral Substance.

tween the bones. The design of it is to distribute the friction over a larger surface, as well as to diminish it.

FIG. 91.



162. In Fig. 90 we see the mode of attachment between the vertebrae and ribs which is that of three distinct ligaments to each rib, besides one common to each pair of ribs. Fig. 91 shows the anatomy of the elbow-joint. Here are no less than four distinct ligaments. We see in Fig. 92 the liga-

An Internal View of the Elbow-Joint. 1, The Capsular Ligament. 2, 2, The Internal Lateral Ligament. 3, The Coronary Ligament. 4, The Ligamentum Teres. 5, The Interosseous Ligament. 6, The Internal Condyle, which conceals the Capsular Ligament behind.

162. Describe the ligaments in Figs. 90, 91, 92 and 93. 163. How are the joints lubricated?

ments which unite the lower end of the fibula to the tibia and the tarsal bones, and in Fig. 93 the ligaments of the foot.

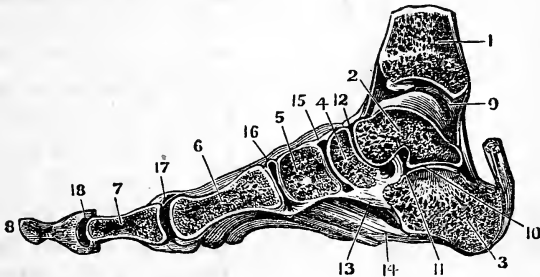
163. Synovial Membrane and its Secretion.—The lubrication of the joints is effected by means of a thin membrane lining their cavities which secretes an oily substance called the Synovia, (Fig. 94, p. 74), that is constantly applied to the opposing surfaces. In health the action of the joint stimulates this membrane to the secretion of a proper amount of

FIG. 92.



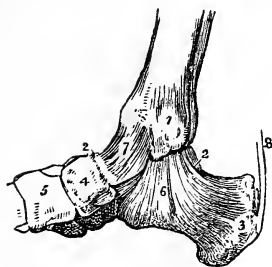
A Posterior View of the Ankle-Joint of the Left Side. 1, The Interosseous Ligament of the Bones of the Leg. 2, The Posterior Inferior Ligament connecting the Tibia and Fibula. 3, The Transverse, or Long Fibres of the same Ligament. 4, The Internal Lateral Ligament. 5, The Posterior Fasciculus of the External Lateral Ligament. 6, The Middle Fasciculus of the same. 7, The Synovial Capsule. 8, The Os Calcis.

FIG. 93.



A Vertical Section of the Ankle-Joint and Foot of the Right Side. 1, The Tibia. 2, The Astragalus. 3, Os Calcis. 4, The Scaphoides. 5, The Cuneiforme Internum. 6, The Metatarsal Bone of the Great Toe. 7, The First Phalanx of the Great Toe. 8, The Second Phalanx of the Great Toe. 9, The Articular Cavity between the Tibia and Astragalus, with its Articular Adipose Matter. 10, The Synovial Capsule between the Astragalus and Calcis. 11, The Calcaneo-Astragalian Interosseous Ligament. 12, The Synovial Capsule between the Astragalus and Scaphoides. 13, The Calcaneo-Scaphoid Ligament. 14, The Calcaneo-Cuboid Ligament. 15, The Synovial Capsule between the Scaphoides and Cuneiforme Internum. 16, The Synovial Capsule between the Cuneiforme Internum and the First Metatarsal Bone. 17, The Metatarso-Phalangeal Articulation of the Great Toe, with the Sesamoid Bones below. 18, The Phalangeal Articulation of the Great Toe.

FIG. 94.



An Internal View of the Ankle-Joint of the Right Side. 1, Internal Malleolus. 2, 2, Part of the Astragalus, the rest being concealed by Ligaments. 3, Os Calcis. 4, Scaphoides. 5, Internal Cuneiform Bone. 6, Internal Lateral, or Deltoid Ligament. 7, The Synovial Capsule, covered by a few Fibres of a Capsular Ligament. 8, Tendo Achillis. A small Bursa is seen between this Tendon and the Tuberosity of the Os Calcis.

synovia, the superabundance of which (when it is present) is removed by the absorbent vessels. This lubricating fluid, however, is not poured out directly upon the ends of the bones, but upon smooth and elastic cartilage, which is found in every joint, not only for furnishing a smooth articular surface, but also to diminish the force of jars by its elastic character.

FUNCTIONS OR USES OF THE BONES.

164. The uses of the bones may be classed under three divisions :

First, for a framework to the whole system.

Second, to furnish points of attachment to muscles and ligaments.

Third, to protect the softer parts.

165. A Framework. Ligaments used as Braces and Pins. —Exactly as a human architect plans and constructs a frame to the house, so the Great Architect has formed the bones. Each bone is fitted exactly to the position, size, and use of the part where it is placed, and nowhere can a supernumerary bone be found. In the house to be built, braces and joining pins must be employed, and those generally of a tougher material than the frame itself. So in the human body, liga-

Why is cartilage useful in the lubrication of joints? 164. Give the uses of the bones as classed above. 165. Compare the bones and ligaments with the timbers, braces and pins of a house.

ments and cartilage exist wherever two opposite extremities need strength and support to keep them in their places. In the railway locomotive immense strength is required, and at the same time perfect freedom of motion in certain positions, all of which is effected by the ponderous bars, levers and wheels, perfectly secured by bolts, keys and screws. But in the human frame by how much more simple means is the same end secured. No angular or cylindrical couplings secure the human joints, though beautifully adapted to produce movement in every direction, and no attention or care is necessary to lubricate and preserve in good condition the working parts of this machine, but a few tough fibers and membranes, secure at once in a most perfect manner every portion of the frame, and provide at the same time means for its lubrication.

166. Use of the Anomalous Forms of Bones.—The bones are fitted for the attachment of muscles and ligaments. Hence it is that they are of such anomalous and curious forms, apparently constructed without design or purpose. But as we study them, and understand the various motions which they must perform, as well as the organs which many of them must protect, or provide space for, we find that it is impossible to improve in the slightest degree on the construction of the skeleton. The size, the form, the quality of material, the exact position of every process, curve and foramen of the bones, and the manner in which all are arranged, are most wisely adapted to their functions and to the happiness of the vertebrated race.

167. Reason why the Long Bones are Tubes.—In this connection should be mentioned the reason why the long bones are hollow. It is for the same cause that the stems of grasses, grains, and many other vegetables are hollow cylinders, instead of solid rods: to secure great strength with as

166. Why are the bones of such peculiar shapes? 167. Give the reason why many of the bones are hollow.

little material as possible. For example, were the human femur a solid rod, instead of a hollow cylinder, as it now is, it would require a bone twice the diameter of the present one to be sufficiently strong for the purposes required of it. Hence were the whole skeleton constructed on this principle, it would be so cumbersome and heavy that it would require a larger amount of muscle, making the body unwieldy, and thus deprive it of its rapid and easy motion.

168. Protection given to the Brain. Use of the Diploe. Reason for several Bones in the Skull.—The bones afford much protection to all the enclosed and adjacent organs. In the bones of the head, for example, how perfect the guard over the nervous center. Here are three means for protection, two plates of bone, and an intervening cellular space. The outer table being very tough presents a substance somewhat yielding to blows inflicted by pointed substances, and even if the blow be so severe as to cause fracture, this can not extend so far as in a hard and brittle material. And the intervening space or diploë very materially deadens the force of any shock given to the outside of the head, precisely as the springs of a carriage prevent the unevenness of the road from giving the same sudden jolt to the body that is communicated to the wheels. The inner table is necessarily brittle, since the brain demands the firmest possible support. But why is the skull made up of several bones instead of one? In the first place a more symmetrical growth can be effected, provided the points of increase are numerous, and especially so since in early life, while the growth is going on, there is a thin layer of cartilage between the edges of each bone, thus allowing all necessary motion; secondly, because a fracture can not extend further than a suture, as all the vibrations are overcome by the interposition of any soft substance like cartilage. And for this

163. How do the bones afford a protection to the softer parts? What is the use of the diploë in the bones of the skull? State the reason of several bones in the skull.

reason the jar of any blow is greatly lessened by the same cause.

169. Use of the Ribs.—Again we see the bones of the thorax arranged for the protection of the enclosed organs. Within this cavity are organs delicate and easily destroyed, but which require elastic and movable walls. The elasticity is easily gained by the cartilaginous portion of the ribs attached to the sternum, which yields considerably upon pressure; and the motion and consequent enlargement is effected by the oblique position of the ribs, as they run downwards and forwards from their articulation with the vertebræ. As the vertebral extremity is the fixed point, of course the elevation of the sternal end will enlarge the cavity of the thorax antero-posteriorly. Another use of the cartilaginous extremity of the ribs is to lessen the chance of fracture. The thorax is exposed to blows and falls more than many other portions of the body, and therefore more exposed to fracture. For instance, if a person suddenly falls to the ground, the head by an instinctive movement is raised, while the trunk or extremities receive the force of the shock. Also the head or extremities can by rapid movements be suddenly removed from the contact with missiles, while the body, comparatively unwieldy, must meet the blow.

170. Use of the Innominata.—The expanded condition of the Innominatum affords service and protection in different ways. A depression, or cup-shaped cavity is thus made for giving a firm support to the organs contained in the abdomen, as well as a solid foundation to the spinal column. It however renders especial service by furnishing a powerful point of attachment for many of the muscles both above and below: those which form the walls of the abdomen, and many of those which move the extremities.

171. Why there are so many Bones in the Spinal

169. Describe the uses of the ribs, and the reason why they are partly made up of cartilage. Why do they run obliquely from the points of attachment? 170. Explain why the Innominata are so broadly expanded.

Column.—A large number of bones in the spinal column is necessary in order to give flexibility to the body. Were the number considerably less, the movements of the trunk would be attended with much more difficulty than at present, and be devoid of grace. And were the separated vertebræ long bones, they would be much more easily broken, thereby endangering the spinal marrow. Another reason for the great number of these bones, is the necessity of the elastic cartilage between them, to protect the brain. Were the joints fewer, in order to give equal protection to the brain from jars, this cartilage must of necessity have been greatly thickened, thereby weakening the joint, and injuring it as a central axis of support to the whole body, and also increasing the liability to dislocations, as well as greatly endangering life, by pressure upon the spinal cord.

172. **Use of the Clavicle.**—The value of the clavicle lies in keeping the upper extremity in its proper position, so as to prevent the humerus from coming forward towards the middle portion of the body. By its direct resistance it also assists in some muscular actions, such as lifting heavy weights with the hands.

173. **Need of two Bones in the Fore-Arm.**—The use of two bones in the fore-arm, as already mentioned, is to produce the movements of supination and pronation. And since these movements are of primary importance, and one bone can not answer this end, two are provided. Again, if one be fractured, the other will act as a splint for keeping the broken one in place, greatly superior to the artificial splint, because the natural splint needs no compression.

174. **Why several Bones in the Carpus.**—In the carpus are found eight bones, and yet we know there is but little motion between them. The reason why exactly this number

171. What is the reason why so many bones are placed in the spinal column? What is the use of the intervertebral substance? 172. What service does the clavicle render to the upper extremities? 173. Why are there two bones in the fore-arm? 174. What can be said of the many bones of the carpus?

is required, is not so easily explained, but it is evident that one bone could not perform their function, nor the prolongation of the radius and ulna to the metacarpus. Several bones are required in order to give easy and graceful motion to the wrist, as well as strength. One bone could not answer the purpose, since the very many offices, which the hand has to perform, could not be effected, unless the wrist bones were very strongly bound together, and flexible to a certain extent. The arrangement of the bones in two rows allows a little movement of the hand upon the wrist.

175. *Function of Metacarpus.*—The metacarpus of five long bones gives support to the fingers. They are long rather than short bones, in order to give slenderness to the hand, and also to afford a solid surface for the fingers to meet in the act of prehension.

176. *Need of three Phalanges to the Fingers, and two Phalanges to the Thumb.*—The phalanges of each finger are three in number, whilst those of the thumb are but two. The obvious reason of this is to give greater firmness to the thumb, and flexibility to the fingers. The hand in man differs from the anterior extremity of all other animals in the power of perfectly opposing the thumb to each of the fingers, which of course gives him a great superiority in all delicate manipulations, and especially in grasping minute objects. And it is easy to see that a third phalanx in the thumb would not only diminish the firmness of this member, but would render the hand an awkward and clumsy organ, instead of an instrument beautifully and perfectly adapted to the multifarious offices which it has to perform.

177. *The great Length of the lower Extremities. Peculiarities of the Femur.*—The value of the great length in the lower extremities, is manifest as a means of rapid pro-

Why would not one bone be sufficient? 175. The use of the metacarpus. 176. Why are there but two phalanges in the thumb and three in each finger? What would be the effect of a third phalanx in the thumb? 177. Why are the lower extremities proportionally longer than the upper?

gression, and also for affording a firm support to the trunk when engaged in the various kinds of labor. Were these extremities much shorter than they now are, walking would not only be a tediously slow process, but a laborious one. The femur has some remarkable peculiarities. In the first place it presents in its articulation with the innominatum the most perfect specimen of a ball and socket joint in the system. Besides this it bends at nearly a right angle at its upper end, making what is called the neck, and here it is that the fracture of the thigh-bone generally occurs. The use of this curvature is to place the points of support for the trunk as far as possible from the center of gravity of the body, thereby giving the body the most secure position on the lower extremities, and especially for the attachment of powerful muscles to move the thigh and leg, as well as to maintain securely the trunk when the legs are the fixed points. This projection is called the Trochanter process, and is spongy or cellular in its structure. And it is not a little interesting to notice, when this process is sawn through in a perpendicular direction, that the cells are arranged in an arched form from below upwards, thereby greatly aiding the strength of the bone. The same arrangement is seen in some other bones of the body, when they are in an exposed position. The lower extremity of this bone, as has already been mentioned, is greatly expanded, in the shape of two condyles for the firm articulation with the tibia. The necessity for this lies in the fact that the knee-joint is one of the most exposed joints in the whole body, and the one which receives the hardest strain. The protection of the nerves and blood vessels, which are sent to the leg, is also worthy of a notice. It is effected by a deep groove between the condyles on the backside of the leg, which guards these vessels from blows in every direction except behind, from whence they are the least apt to come.

What remarkable joint between the femur and the innominata? What is the arrangement of the cellular structure in the upper part of the femur? Why has the femur so large processes on its lower extremity?

178. Use of the Tarsus.—In the Tarsus we see the value of several bones instead of one. It is the movement of these upon one another that imparts elasticity to the step and firmness of support to the whole body; and hence it is that all artificial legs produce a limping motion in the body. By no mechanical contrivance can the suppleness of the tarsus and of the muscular actions be supplied.

179. Two Bones in the Great Toe, and three Bones in all the Others.—The great toe of the foot, like the thumb of the hand, has only two phalanges. This is mainly for the purpose of securing greater strength to the foot in walking and standing. It is also of service for opposition to the other toes, as is seen in those rare cases of persons deprived of their upper extremities, who can readily make use of the foot for many of the delicate purposes to which the hand is adapted, such as writing, using scissors, and placing the crystal in a watch. The remaining toes, like four of the fingers, receive a tendon only at the base of the second and third phalanx, the first one being interposed merely to give strength and slenderness to the extremities, as well as the power of surrounding objects in the act of prehension. The slenderness of the fingers above the toes is a distinguishing characteristic of man, showing that the office of the foot is merely to support the body on the ground, and of the hand to perform the business of every-day life in its ten thousand forms.

HYGIENIC INFERENCES.

180.—1. Reason of Distorted Bones.—In the early life of man and other vertebrate animals, the animal portion of bones greatly predominates over the earthy constituents, and hence they yield more readily to pressure, but are not so

178. How do the bones of the Tarsus give elasticity to the step? 179. How do the phalanges of the foot compare with those of the hand in number? Why are the bones of the hand longer than those of the foot? 180. What kind of matter predominates in the early life of bones?

liable to break as in older persons. This is the reason why falls and blows so seldom do much injury to children. It is also the reason why distortions and curvatures of some of the bones are so common, since too often children are either urged or permitted to use their limbs excessively before their bones are made solid by the deposition of earthy matter. These distortions are most common in children who are weak and sickly, because in them the recuperative powers are small.

181.—2. Danger of Constrained and Unnatural Positions in Children.—Hence we infer that children should not be confined in any unnatural or constrained position, but allowed to move freely in whatever direction nature may demand. And all punishments of this sort, inflicted by parents, guardians, and school teachers upon young persons, such as standing on one leg, or holding a book with an extended arm for a long time, are dangerous and ought to be proscribed, since they are too often the cause of bow legs and curvature of the spinal column.

182.—3. Cause of the Rickets.—The disease known as Rickets is produced by imperfect nutrition of the bones. This is generally, though not always, the result of poverty or vice, or both combined. The direct cause of the disease is a deficiency of earthy matter in the bones. This is either absorbed or never produced, and as a result the bone is softened, and by the tonicity of the muscles the body is drawn into unsightly deformity. An observance of the laws of health is the best medicine for this disease.

183.—4. Need of Cleanliness of the Teeth—Tooth Powders—Tooth Picks—Decayed Teeth—Worthless Teeth should be Extracted.—From the almost inevitable exposure of the teeth to mechanical and chemical agents, we see that they need considerable care and attention. *They need to be*

Why do falls and blows seldom injure children as they do adults? In what children are distortions the most common? 181. Why should children be unconstrained in their bodily exercise? What is said about punishments that distort the bones of children? 182. What is the usual cause of Rickets? What is the best medicine for it? 183. Give the most important hygienic rule for the preservation of the teeth.

kept clean. This can ordinarily be accomplished by the use of a soft tooth brush and pure water thoroughly applied at least once in the twenty-four hours. A tooth-powder of an alkaline character, or, what is the same thing, clean toilet soap, can be occasionally used with benefit. A tooth pick should be possessed and used by every gentleman *and lady too*, though it should be made of wood, ivory, tortoise-shell, bone, quill, or some substance softer than the tooth itself. If the teeth are very closely set together, frequently drawing a thread between them will aid in preventing decay. If any of them have begun to decay, a good dentist should be consulted as soon as possible, and the cavities filled with gold, since artificial teeth can never be so valuable as natural ones, even though partly filled with gold. When teeth are past filling they should be removed, as they are the means of producing decay in others, as well as many pains called neuralgia.

184.—5. The Teeth not to be Used on very Hard Substances.—The teeth should be used only for the purposes for which they were designed. The teeth of squirrels, rats, and beavers were made expressly for cutting wood and gnawing open nuts, but not so with the human teeth. Even the constant biting of thread, the holding of a pencil or tobacco-pipe between the teeth, and especially the cracking of nuts, are practices very injurious, and often cause the decay of these organs.

185.—6. Teeth Generally Decay Early in Life.—Experience shows that teeth decay the most rapidly in the early part of life, generally between the ages of fifteen and thirty. Hence youth need to take especial care to preserve them, not only on account of the pain and deformity which their loss occasions, but because of their remote effects upon the voice and especially upon the digestive organs.

What kind of tooth powder is the best? Who should use tooth picks? What treatment should be given to decaying and decayed teeth? What substance alone should teeth be filled with? 184. For what purposes should human teeth never be used? 185. In what period of life do teeth decay the fastest? What are important reasons for an especial care of the teeth?

186. *Classification of Animals.*—The highest and most competent authorities differ widely in their attempts to classify the Animal Kingdom; that is, to divide it into smaller groups, which are Sub-Kingdoms or Provinces, Classes, Orders, Families, Genera, and Species. We have no room, had we the ability, to decide these difficult questions. There is, however, a general acquiescence in the principle first introduced by Cuvier, that animals were created on four great types or plans, which he calls Vertebrata, Articulata, Mollusca, and Radiata. The discrepancy lies chiefly in the subdivisions of these leading groups. We shall merely present the classifications of two of the most eminent living anatomists and zoologists—Professor Louis Agassiz of Cambridge, and Sir Richard Owen of London—not attempting to decide between them.

187. Agassiz divides the whole animal kingdom into four great branches, the same as those named above. The Vertebrata he divides into eight classes: 1, The Myzontes, subdivided into two orders; 2, Fishes proper, into two orders; 3, Ganoids, into three orders; 4, Selachians, into three orders; 5, Amphibians, into three orders; 6, Reptiles, into four orders; 7, Birds, into four orders; 8, Mammalia, into three orders.

The Branch Articulata he divides into three classes: 1, Worms, with three orders; 2, Crustacea, with four orders; 3, Insects, with three orders.

The Branch Mollusca he divides into three classes: 1, Acephala, with four orders; 2, Gasteropoda, with three orders; 3, Cephalopoda, with two orders.

The Branch Radiata he divides into three classes: 1, Polypi, with two orders; 2, Acalephæ, with three orders; 3 Echinoderms, with four orders.

188. Owen calls the above-named four divisions of the Animal Kingdom, Provinces. The Province Vertebrata he subdivides into four classes: 1, Mammalia, with fifteen orders; 2, Aves, or Birds; 3, Reptilia, with fifteen orders; 4, Fishes, with eleven orders. His fifteen orders of Mammalia are: 1, Monotremata; 2, Marsupialia; 3, Rodentia; 4, Insectivora; 5, Cheiroptera; 6, Bruta; 7, Cetacea; 8, Sirenia; 9, Toxodontia; 10, Proboscidea; 11, Perisodactyla; 12, Artiodactyla; 13, Carnivora; 14, Quadrumana; 15, Bimana.

The Province Articulata he divides into six classes: 1, Arachnida, with four orders; 2, Insects, with eleven orders; 3, Crustacea, with eleven orders; 4, Epizoa, with three orders; 5, Anellata, with four orders; 6 Cirripedia, with three orders.

The Mollusca he divides into six classes: 1, Cephalopoda, with two orders; 2, Gasteropoda, with ten orders; 3, Pteropoda, with two orders; 4, Lamellibranchiata, with two orders; 5, Brachiopoda; 6, Tunicata, with two orders.

The Radiata he divides into nine classes: 1, Echinodermata; 2, Bryozoa; 3, Anthozoa; 4, Acalephæ; 5, Hydrozoa; 6, Cœlelmintha; 7, Sterelmintha; 8, Rotifera; 9, Polygastria.

189. To the above Animal Kingdom Prof. Owen has added another kingdom of organisms, "mostly of minute size, and retaining the form of nucleated cells, which manifest the common organic characters, but without the distinctive superadditions of true plants or animals." These he calls Protozoa, and arranges in three classes: 1, The Amorphozoa, or Sponges; 2, the Rhizopoda, which are the Polythalamia, or Foraminifera; 3, the Infusoria, or Animalcula—the last two classes being mostly microscopic.

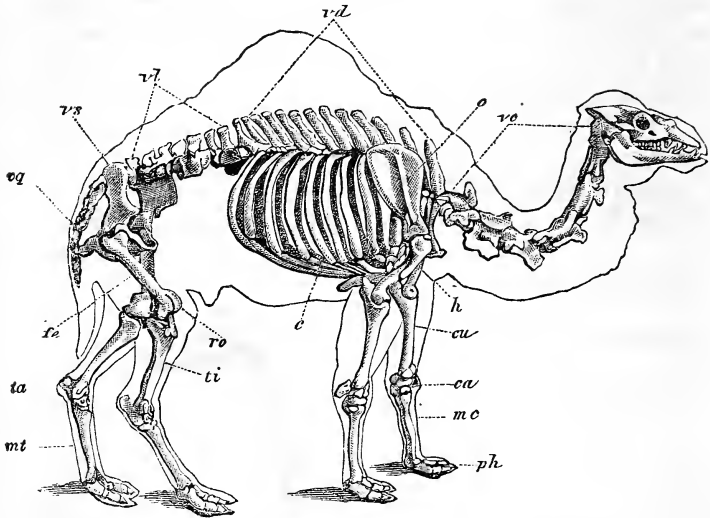
COMPARATIVE OSTEOLOGY.

191. *Microscopic Structure.*—In microscopic structure and chemical composition the bones of mammals, including man, and of all vertebrates are essentially the same, and in their general outline a considerable degree of correspondence can be traced between many of the bones of the human system, and those performing similar functions in the lower animals. Thus we almost always find the femur to have a globular head on its upper extremity supported by a neck which makes a considerable angle with the shaft, and the two large condyles on the lower extremity.

192. *Spinal Column of Mammals. Cervical, Dorsal, Lumbar, Sacral, Caudal Vertebrae.*—In Mammals the Spinal Column is made up of five classes of vertebrae: the cervical, of the neck; the dorsal, of the back; the lumbar, of the loins; the sacral, of the hip; and the caudal, of the tail. The Cervical vertebrae, with but two or three exceptions in all mammals, consists of seven in number. The average number of the Dorsal is thirteen, the Bats having eleven, and one of the Sloths

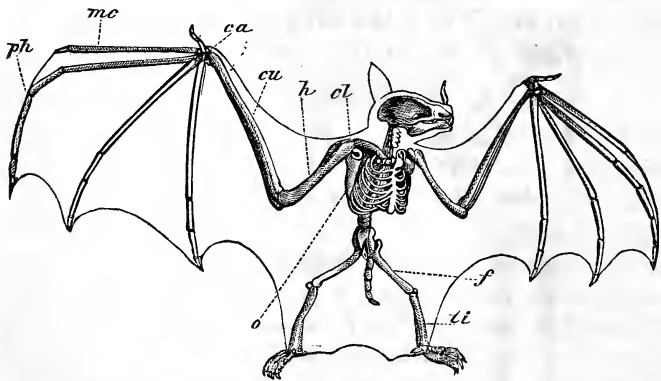
191. What is the microscopic structure of the bones of Mammals? What about the general correspondence in outline, etc.? Instance the femur.—192. What are the five classes of Vertebrae? How constant is the typical number seven for the Cervical vertebrae? Give the average number of the Dorsal.

FIG. 95.



Skeleton of the Camel. *v. c.* Cervical Vertebrae. *v. d.* Dorsal Vertebrae. *v. l.* Lumbar Vertebrae. *v. s.* Sacral Vertebrae. *v. g.* Caudal Vertebrae. *o.* Scapula. *h.* Humerus. *c.* Ribs. *cu.* Ulna. *ca.* Carpus. *m. c.* Metacarpus. *ph.* Phalanges. *fe.* Femur, *ro.* Patella. *ti.* Tibia. *ta.* Tarsus. *m, t.* Metatarsus. *cl.* Clavicle.

FIG. 96.



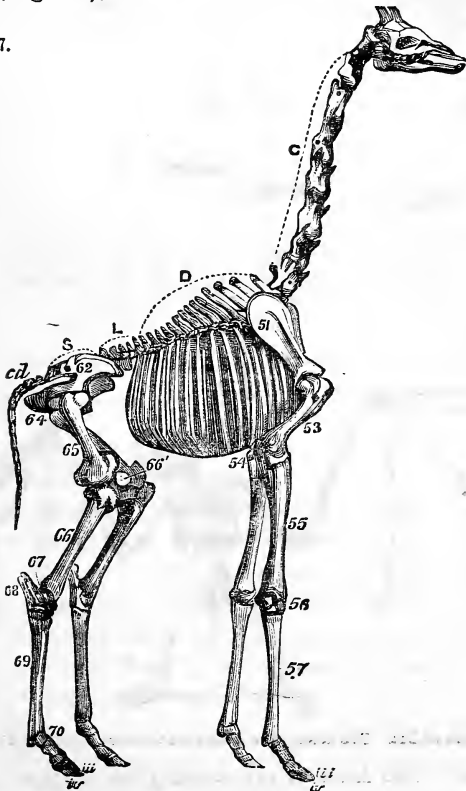
Skeleton of Bat. The descriptive letters are the same as in Fig. 95.

twenty-three. The Lumbar are usually the largest in size, and their range is from two to nine. The Sacral consist

usually of four, but vary from one to nine, and as in man, are almost always consolidated. The Caudal vary exceedingly in number, sometimes amounting to forty-six. When of this number, they gradually dwindle away towards the extremity of the tail, and lose the characteristics of vertebræ, and become mere ossicles or bits of bone.

193. On what Length of Neck depends.—Hence we see that the length of the neck in quadrupeds does not depend on the number, but on the length of vertebræ, since the Cameleopard (Fig. 97),

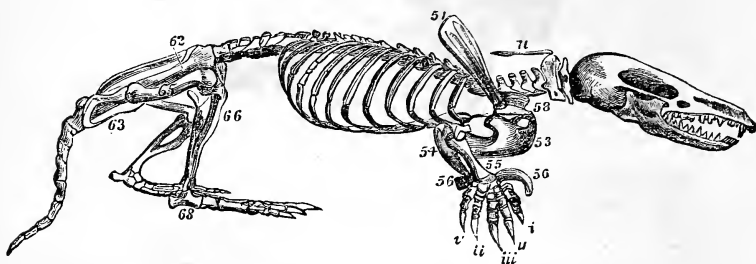
FIG. 97.



Skeleton of Cameleopard. *C.* Cervical Vertebræ. *D.* Dorsal Vertebræ. *L.* Lumbar Vertebræ. *S.* Sacral Vertebræ. *cd.* Caudal Vertebræ. 51. Scapula. 53. Humerus. 54. Ulna. 55. Radius. 56. Carpal Bones. 57. Metacarpus. *iii.* and *iv.* Phalanges. 62. Innominate. 64 and 65. Femur. 66'. Patella. 66. Tibia. 67 and 68. Tarsus. 69. Metatarsus.

which has the longest neck, has only seven cervical vertebræ, the same number with the Mole (Fig. 98), an animal with

FIG. 98.



Skeleton of the Mole. The illustrative Figures represent the same as in Fig. 97.

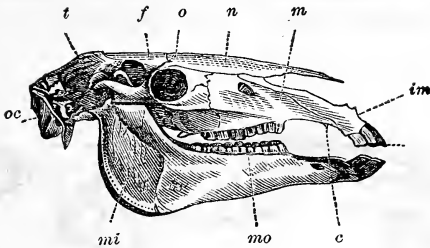
one of the shortest necks among quadrupeds. Cuvier states that in general the length of the neck is such, that, added to the head, the length of both is equal to the height of the animal's shoulders above the ground. If this were not the case, grazing animals could not reach their food, nor any quadrupeds their drink without bending the legs.

194. Shape of Body.—The shape of the body of quadrupeds, whether slender, or short and thick, depends on the number and size of the Lumbar and Dorsal vertebræ.

195. Bones of Skull. Elephant's Head. Styloid, and Tympanic Bones.—The general arrangement of the bones of the skull, as well as their number, corresponds very nearly with those of man. The two Parietals are usually small bones, and sometimes united into one. This is true of the Horse and the Bats. In the Hog and Rhinoceros the two parietal bones are united in one, while their frontal bone is

What peculiarity about Lumbar? What of the Sacral? How large a number of Sacral are sometimes found? 193. Upon what does the length of neck in quadrupeds depend on? Instance the Giraffe and Mole. What is the general rule about the length of the neck? 194. What does the shape of the body mainly depend on? 195. How do the Parietals sometimes differ from man?

FIG. 99.



Skull of Horse. *oc.*, *t.*, *f.* Occipital, Temporal, and Frontal Bones. *n.*, *m.*, *im.* and *mi.*, Nasal, Superior Maxillary, Intermaxillary, and Mandibular Bones. *o.* Orbit. *i.* Incisive Teeth. *mo.* Molar Teeth.

in two pieces. In nearly all the orders of mammalia this bone (the frontal) is always found in two pieces. In the Elephant the bones of the cranium are all united into one at an early period in life, forming but one piece, in order probably to make it sufficiently strong to support the great weight which is brought upon these bones by the tusks and proboscis. The Styloid process of the temporal bone is usually in mammals a separate ossicle. The bone which contains the organ of hearing in all mammals, except man and the Apes, is a separate bone called the Tympanic, and is not simply the petrous portion of the temporal as in man.

196. **Bones of Face, Intermaxillaries, Lower Jaw.**—In the Face too the bones correspond very nearly with those in man. The essential difference is found in the upper jaw. Instead of the two superior maxillaries meeting each other on the median line of the body in front, there are two other bones between them called the Intermaxillaries. These are very conspicuous in animals provided with large canine teeth, or tusks, as the Elephant and Squirrel. The Lower Jaw in

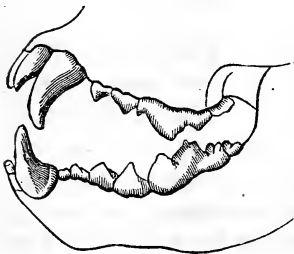
What peculiarity about the bones of the Elephant's skull? What bone is wanting in the Whale? Describe the Tympanic Bone. 196. In what respect do the bones of the face in Mammals differ from those in man? Where are the Intermaxillaries?

quadrupeds generally consists of two pieces, the division being made on the median line of the body. In the Hog, Horse and Cow it consists of a single bone. In the Greenland Whale it is in its simplest form, which is that of two arched ribs.

197. Form of Skull, of Orang Outangs.—Viewed as a whole the form of the skull departs most from that of man in the lowest orders. In the *Ornithorynchus* the face is prolonged into a beak or bill, and in the Horse the facial portion of the head is four times larger than the cranial, exactly the reverse of the case in man. In the young Orang Outangs the form of the skull very closely resembles that of man, and in the adult the size of the exterior of the cranium nearly equals that of man, though its capacity is considerably less.

198. Teeth of Quadrupeds, Carnivorous, Herbivorous, Insectivorous and Barbed Teeth.—The Teeth of Mammals vary exceedingly. They may, however, be classed under the two divisions of flesh and vegetable eating, according to the food of the animal. Those made to live on meat are sharp and

Fig. 100.



Teeth of a Lion (Carnivorous Animal.)

pointed, for simply tearing the flesh into such small portions that it can be swallowed, while those eating herbs and grass, have the front teeth with sharp edges like that of a knife for cropping the food, and back teeth with flat surfaces, or vertical ridges of enamel interspersed between the ivory or dentine, which act the same part when brought together with a lateral motion, as do the upper

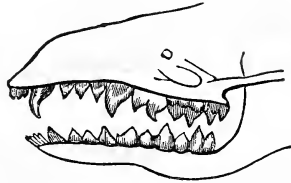
What of the Lower Jaw? 197. In what orders does the head differ most from that of man? How does the skull of the Orang Outang differ from that of man? 198. What are the two kinds of teeth among mammals? Describe each. Give the reason why the teeth are furnished as they are.

FIG. 101.



Teeth of an Herbivorous Animal.

FIG. 102.



Teeth of an Insectivorous Animal.

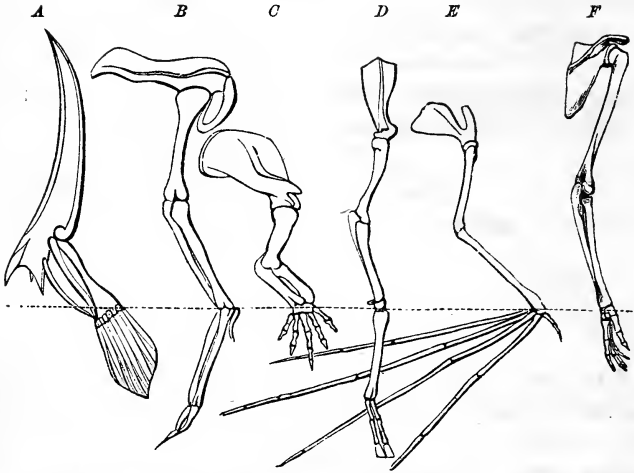
and nether millstone for grinding grain. Those which live upon small insects have conical teeth with corresponding depressions in the opposite jaw in order to crush the skeletons and envelops of their prey. The Seals, which live on Fish, are provided with barblike appendages similar to those on fish-hooks, in order that they may hold their slippery prey.

199. *Humerus, in Burrowing Animals.*—The *Humerus* is generally a long cylindrical tube, with a large rounded head at its upper extremity. But in swimming and burrowing animals it is a short and curved bone, with each extremity very much modified for the attachment of muscles, since the fore-legs of such animals need to be used with great frequency and force.

200. *Bones of Fore-Arm. Carpus, Metacarpus, Phalanges.*—The element in which mammals live, greatly modifies the bones of the fore-arm and hand. (Fig. 103, p. 92.) In general there are two bones in the fore-arm, and but few animals have the power to move these one upon another like man. The *Carpus* is constantly made up of two rows, though not of the same number. They vary from five to eleven. The *Metacarpus* consists of five elongated bones for the most part. But these are three in the *Rhinoceros*, and one with two

What is remarkable about the teeth of the Seal? 199. What is the general outline of the *Humerus*? In what animals is it modified? 200. What effect has the element, in which animals live, upon the anterior extremities? How do the *Carpal Bones* range in number? What are the exceptions to the typical number five of the *Metacarpus*?

FIG. 103.



Anterior Members of different Animals. *A.* Fish. *B.* Bird. *C.* Dolphin. *D.* Deer. *E.* Bat. *F.* Man.

rudimentary bones in the Horse. From one to five fingers are usually found, of which the thumb is generally rudimentary,

FIG. 104.



Hind Foot of Horse. *t.* Tibia. *ta.* and *ta'.* Tarsus. *c.* Metatarsus or Canon Bone. *a.* Rudimentary Bone. *p.*, *pi.*, and *pt.*, first, second and third Phalanges.

FIG. 105.



Foot of Stag. (Representative letters the same as in the last figure.)

consisting only of a single bone. The Elephant has five toes, the Hog four, the Rhinoceros three, the Cow two, and the Horse one. Sometimes the longest finger (paddle) of the Whale contains eleven bones. In burrowing and swimming animals the fore-feet are generally the largest, and among some quadrupeds the reverse is the case. The posterior extremities of quadrupeds are usually less modified than the anterior ones, as they are used mainly for support and progression.

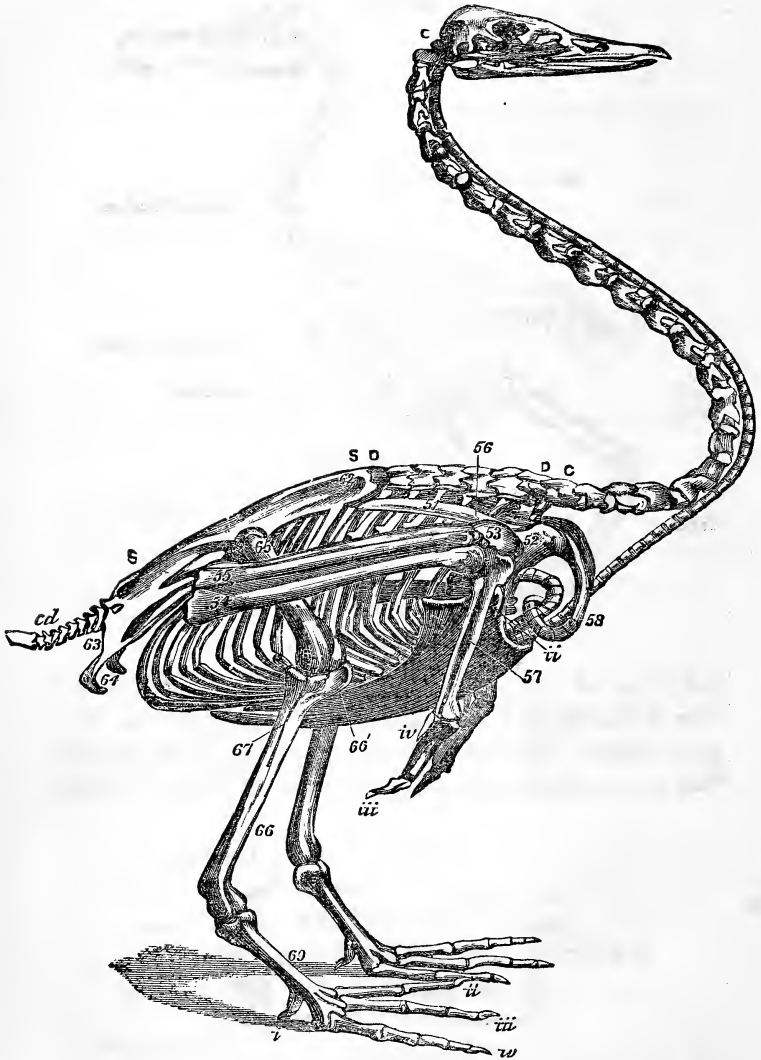
OSTEOLOGY OF BIRDS.

201. *Vertebræ, Cervical, Dorsal, Caudal.*—Birds exhibit several peculiarities in their Spinal Column. The number of Cervical *Vertebræ* is much greater than in mammals, giving them long and flexible necks. (Fig. 106, p. 94.) The number is between ten and fifteen, but the white Swan has twenty-three. The Dorsal *Vertebræ* vary in number from seven to nine, and admit of but little motion upon each other, many of them being frequently anchylosed together, as in the human sacrum. (Fig. 107, p. 95.) The design of this is to give the firmest point of attachment to wings that can be secured. The Caudal *Vertebræ* are hollow and form a complete canal for the spinal marrow. The last one has a large disc-shaped process upon it for the support of the long feathers of the tail.

202. *Bones of Head, Os Quadratum, Jugal Bone.*—The bones of the head correspond in number and position for the most part with those of the mammalia. (Fig. 108, p. 95.) They are, however, united together at a very early period, and the sutures can not be recognized except in very young subjects. One point of difference between these skulls

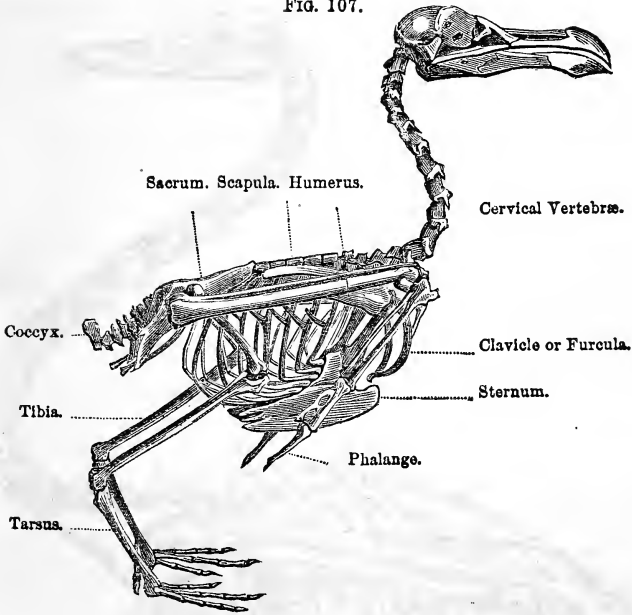
What are some modifications of *Phalanges*? 201. Compare the Cervical *Vertebræ* of Mammals with those of Birds. What number of Cervical *Vertebræ* has the Swan? Why are the Dorsal *Vertebræ* usually firmly fixed together? What peculiarity of the Caudal *Vertebræ*? 202. What can be said of the Sutures in the head of birds?

FIG. 106.



Skeleton of Swan. *C. C.* Cervical Vertebrae. *D. D.* Dorsal Vertebrae. *S. S.* Sacral Vertebrae. *cd.* Caudal Vertebrae. 51. Scapula. 52. Coracoid Bone. 53. Humerus. 54 and 55. Radius and Ulna. 56. Carpus. 57. Metacarpus. 58. Furcula. 62. Innominata. 63. Sacrum. 64. Pubis. 65. Femur. 63'. Patella. 67. Fibula. 69. Tarsus Metatarsus. *i., ii., iii., iv.* Phalanges.

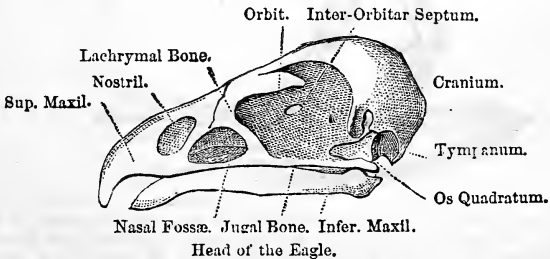
FIG. 107.



Skeleton of the Goëland.

and those of the mammals is that the occipital bone consists of four parts instead of one. A small bone, too, is always present called the Os Quadratum, in close proximity with the occipital, temporal, and maxillary bones. A Jugal

FIG. 108.



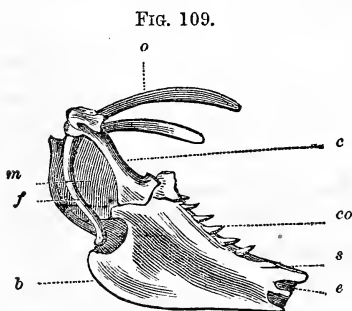
Head of the Eagle.

What bone in the skull of birds that demands attention?

Bone is also found which is similar in position to the zygomatic process of the temporal bone in man.

203. Bill.—Teeth are entirely wanting in Birds, their place being supplied by a single horny projection on each jaw known as the Bill. Teeth are not needed by these animals, since mastication, where it is necessary that it should be performed, is done by the gizzard.

204. Ribs.—The Ribs are very firmly articulated with the sternum by bone and not cartilage, so that they have a tendency to keep the thorax as fully distended as possible all the time, which is its natural position.



Bones of Sternum and Shoulder of Birds. *s.* The Sternum. *e.* Notch of the Sternum. *co.* Origin of the Sternal Ribs. *b.* Crest. *f.* Fourchette. *c.* Coracoid Clavicle. *o.* Scapula.

205. Sternum, in what Birds largest.—The Sternum is the most striking of all the bones in a bird. It is the largest bone in their bodies, a flattened and sometimes quadrangular bone, having upon its anterior surface a prominent ridge like the keel of a ship, for the attachment of the pectoral muscles used in flight. The size of this ridge generally stands in direct relation to the powers of rapid flight, and hence in

the Humming Bird, one of the swiftest on the wing, it is proportionally the largest.

206. Clavicles, Coracoid Bone.—The Clavicles of birds present a marked peculiarity. They both unite at their anterior extremity, forming a forked bone known as the Fur-

203. What serves the purpose of teeth for Birds? 204. How does the articulation of the ribs affect the condition of the chest? 205. Which is the largest bone in birds? How may we know the powers of flight in a bird by the keel of the Sternum? 206. What do the clavicles of birds form as they are united together?

cula, merry thought, or wish bone. They also possess another bone which acts the part of a clavicle, called the Coracoid. It reaches from the scapula to the sternum, side by side with the Furcula, and is a principal source of support to the wings in flight. There is a bone analogous to this among some reptiles.

207. Humerus.—The Humerus is generally a larger and stouter bone than the femur, contrary to the relative proportion in man. This is because the anterior extremities of birds are of much more importance in their habits than the posterior ones, since the hind legs in most of the flying birds act merely as a support for the body when at rest, and are not of special service for running or scratching.

208. Bones of Wings, Fingers.—The two bones of the fore-arm are proportionally longer than the same bones in mammals, and are longest in birds of flight. The carpus is represented by two short bones, and the metacarpus is of the same number. In some birds the thumb is entirely wanting, but when present it is made up of two bones. The little finger has only one bone. The middle finger is the longest, consisting of two and even three bones.

209. Femur, Tarso-Metatarsus.—The Femur is both thicker and shorter than the bones below it, which constitute the leg. The Fibula is always, partially at least, united with the tibia at its lower extremity. The Tarsal and Metatarsal Bones are found as one, called the Tarso-Metatarsus, which has at its lower extremity three pulley-shaped heads for the attachment of the toes.

210. Sesamoid Bones.—Sesamoid Bones are abundant in birds, and in many cases even the tendons themselves become

Is this peculiar to birds alone? 207. What is the comparative length and size of the Humerus and Femur in birds? Why are the anterior extremities in most cases the longest? 208. What is said of the two bones of the fore-arm? How many bones are there in the Carpus? Describe the fingers of birds. 209. What peculiarities in the lower extremities of birds? Describe the Tarso Metatarsal Bone. 210. What is said about Sesamoid Bones in birds?

considerably ossified. This is especially true of those in the leg.

211. **Birds Bones are hollow.**—The bones of birds are more or less hollow internally, devoid of marrow, and permeated by air. Hence they are provided with openings connected with the respiratory apparatus through which the air is brought into them. As a general rule the capacity and extent of these openings throughout the skeleton depends on the size of the bird, and its powers of flight, since small though rapidly flying birds have few hollow bones; in larger and higher flying species, however, they are numerous. In the Apteryx of New Zealand there is the greatest want of these cells. This bird has no wings, but can run and even burrow in the earth very rapidly. Those bones which convey the air, differ from all others in appearance by their whiteness and more compactly cancellated or cellular structure.

OSTEOLOGY OF REPTILES.

212. **Number of Vertebræ in Reptiles.**—The Vertebræ of Reptiles vary exceedingly in number. “For whilst in the tailless Batrachia only nine or eight cervical vertebræ are counted, some serpents have full 300.” Those of Batrachians have long transverse processes.

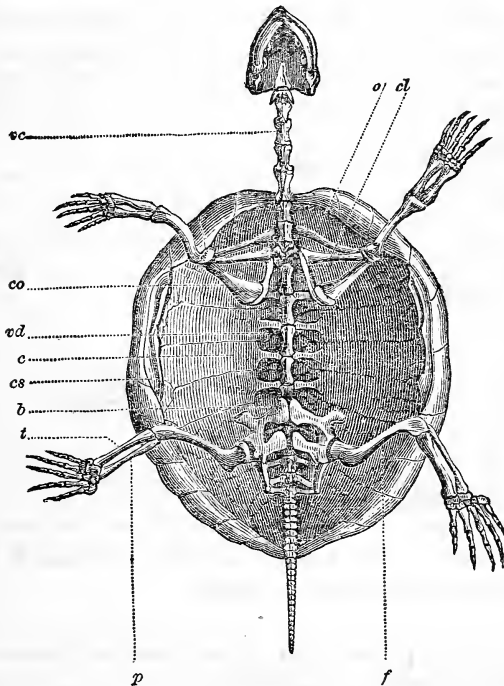
213. **Ribs; Use of Ribs to Serpents.**—“In the serpents the ribs are both very numerous and very movable; where they cease the tail begins; here the Caudal vertebræ may be distinguished from the other vertebræ of the trunk, whilst all distinction of dorsal and lumbar vertebræ fails.” They are

211. Why are birds' bones usually hollow and more or less occupied by cavities? 212. What is the number of vertebræ in Reptiles? 213. Give the number of ribs in Reptiles. How do they differ from those of quadrupeds? Of what service are they to the animal?

valuable instruments of progression, since in many they can be placed upon the ground and used as feet.

214. Shell of Tortoise.—In the Tortoise that portion which is commonly called the shell, is made up of the Cara-

FIG. 110.



Skeleton of the Tortoise; the Plastron has been removed. *vc.* Cervical Vertebrae. *vd.* Dorsal Vertebrae. *c.* Ribs. *cs.* Sternal Ribs.—The Marginal Bones of the Carapace: *o.* Scapula. *cl.* Collar Bone. *co.* Coracoid Bone. *b.* Pelvis. *f.* The Femur. *t.* Tibia. *p.* Fibula.

pace or upper portion, and the Plastron, or lower one. The Carapace seems to be a mere expansion of the vertebræ, and the Plastron an expanded sternum. Hence, as the annexed

214. What is the Carapace and what is the Plastron in the Turtle family? From what bones are they developed?

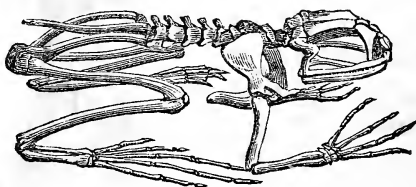
cut shows, the skeleton of the Tortoise is a very simple one, and the skeleton of the Frog, as shown in Fig. 111, is equally simple.

215. Humerus.—The Humerus of the Tortoise is short and very much curved. This is made so in order that the animal may thrust its extremities out of the shell and reach the ground, which could not be done if the humerus were straight as it is in most of the other vertebrate animals.

216. Femur.—The Femur is curved in the same animals for the same reason.

217. Phalanges.—Frogs generally have four fingers, with from two to four phalanges in each finger. Tortoises and Lizards generally have five fingers, and from two to five phalanges in each finger.

FIG. 111.



Skeleton of the Frog.

OSTEOLOGY OF FISHES.

218. Bony and Cartilaginous Fishes.—The skeletons of Fishes are of two kinds, those made up of bony, and those of cartilaginous matter. (Fig. 112.) The microscopic structure of the scale of a Pike is seen in Fig. 113. Of the former kind

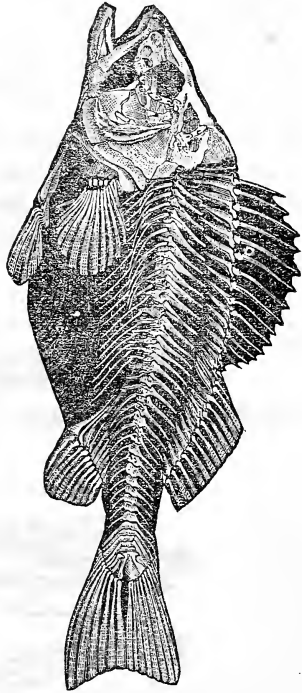
215. Why is the Humerus of the Tortoise curved? 217. How many fingers have Frogs, Lizards, and Tortoises? 213. What are the two kinds of skeletons in Fishes? Give examples of each.

as representatives are the Shad and Flounder, and of the latter, the Shark and Sturgeon.

219. Two Kinds of Vertebræ.—The only kinds of Vertebræ in Fishes are the Dorsal and Caudal. These vary in number from seventeen to more than a hundred. Their bodies (vertebræ) present on both articulating surfaces a conical depression which is filled with a soft matter having the same use as the elastic intervertebral substance in the human vertebral column.

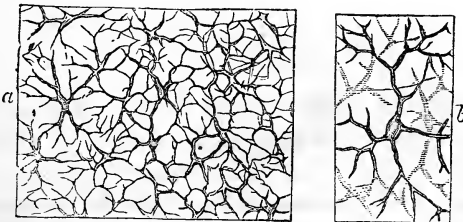
220. No Sternum or Pelvis.—The Sternum and Pelvis are both wanting in fishes, and the anterior and posterior extremities are rudimentary, being represented by fins.

FIG. 112.



Skeleton of the Perch.

FIG. 113.



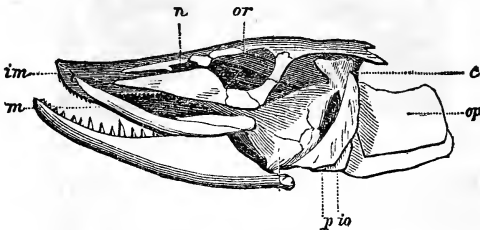
Section of the bony scale of *Lepidosteus*. *a*. Showing the regular distribution of the Lacunæ and of the connecting Canaliculi. *b*. Small portion more highly magnified.

219. What are the only Vertebræ of Fishes? What is peculiar about their articulating surfaces? 220. Why have Fishes no Sternum or Pelvis?

221. Head.—The bones of the Head in this class of animals are numerous and exceedingly complicated, being in fact a difficult portion of study in comparative osteology. It is, however, a subject of great interest to a thorough scholar of this branch of anatomy; but as so little of it can be generalized, it must be omitted here altogether.

222. Great Variety of Teeth.—The Teeth present every possible variety in position and size, and, as Sir Richard Owen says, “they average in number from zero to count-

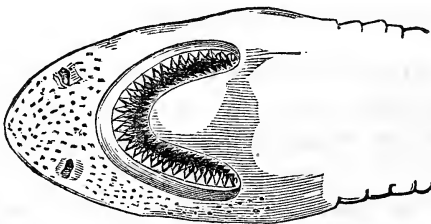
FIG. 114.



Head of the Pike. c. Cranium. n. Nasal Fossæ. im. Intermaxillary Bone. m. Upper Jaw. p, op, io. Bones peculiar to the head of fishes.

less quantities.” Some teeth, in shape and location resemble the pavement of the street, others are of a delicate hook-shape, and others still are fine as hairs, and are located

FIG. 115.



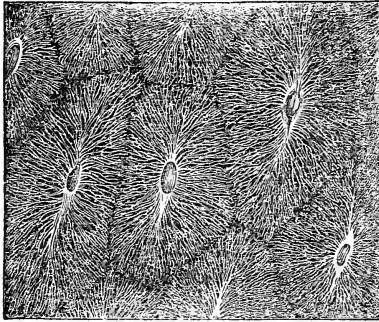
Head of a Shark.

221. What is remarkable with respect to the bones of the Head in this class? 222. What is said about the variety of Fishes' Teeth? How numerous are they found at times?

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on the jaws, tongue, and palate. They are repeatedly renewed during the life of the animal. Fig. 116 represents the microscopic structure of the tooth of an Eagle Ray.

FIG. 116.



Microscopic structure of Tooth of Eagle Ray.

223. **Skeleton, or Harder Parts of Invertebrata.**—The harder parts of invertebrate animals generally differ so much from bones in composition and structure that the term Osteology may perhaps be less proper than that of Skeleton in describing them.

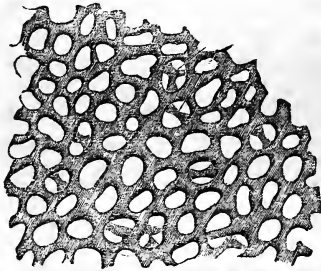
224. **Skeletons of Crustaceans.**—Among the Articulata the Crustaceans have a more or less solid external crust of carbonate of lime in a base of peculiar azotic matter, insoluble in caustic potash, called *Chitine*.

225. **Skeletons of Insects.**—Insects, the most numerous class of articulated animals, have a chitinous covering, generally leathery, but sometimes solid. The Arachnoidea have a similar skin, soft or coriaceous, rarely horny; and the Annelida a very thin epidermis. The Helminthes, Rotatoria, and Turbellaria, reckoned in this branch of the animal kingdom

What is curious about their renewal? 224. Describe the skeleton of Crustaceans?
225. What is the skeleton of Insects?

by some eminent writers, have a skin more or less hard, and sometimes spinous.

FIG. 117.



Microscopic structure of the Spine of Sea Hedge-Hog.

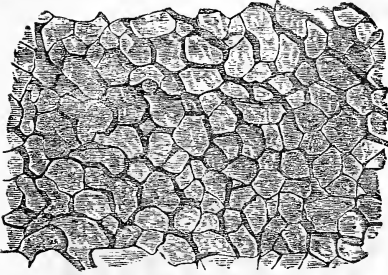
226. Skeleton of the Mollusca.—In all the three great classes of Molluscs, the Acephala, the Cephalophora, and the Cephalopoda, the animal possesses a mantle by which it is able to secrete a solid deposit, mainly composed of carbonate of lime, which it spreads over nearly all the body, and is fastened to it by muscles. In the Acephala this skeleton is in two pieces, called valves; in the Cephalophora, it is in one piece, except that a calcareous plate is attached to the foot to close the orifice. The organic base of these shells sometimes, but rarely, predominates over the calcareous part. In the Cephalopoda there are cartilages for the attachment of muscles similar to the same substance in vertebrate animals. In the Argonauta and Nautilina of this class, the mantle secretes an external shell; but in the Loligina, or Cuttle Fish family, it is internal.

The structure of the shells of Molluscs is often complicated and beautiful.

227. Skeletons of the Radiata.—Among the Polypi some are entirely soft; others have a solid skeleton, which

226. Describe the skeleton of Molluscs. 227. What are the skeletons of Radiates? What is their chemical composition?

FIG. 118.

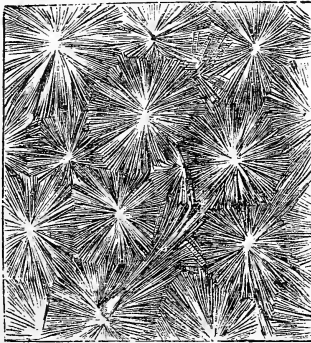


Microscopic view of Shell of Pinna.

is calcareous, horny, or leathery. This skeleton, called a polypary, or in popular language *coral*, is secreted by the skin of the animal, and seems to be truly an internal skeleton. It contains, say ninety-five per cent. of carbonate of lime, some two or three per cent. of fluorides and phosphates, and from four to eight per cent. of organic matter.

The Acalephæ, another class of Radiates, are mostly gelatinous; but a few are cartilaginous, and some have a nuclear skeleton. The Echinodermata, with few exceptions, have an

FIG. 119.



Microscopic section of hinge of Mya showing a crystalline structure.

What is coral? What is the skeleton of other Radiates?

external skeleton highly calcareous. In the Asteroidea there is also an internal articulated skeleton. The structure of these skeletons is too complicated for description here. The Echinidæ are remarkable for calcareous knobs and rays, both sharp and blunt, sometimes several inches long; hence this common name, Sea Hedge-Hog, or Porcupine.

Skeletons of the Protozoa.—The organisms brought together by Prof. Owen under Protozoa, are the Amorphozoa or Sponges, the Foraminifera, and Infusoria, “which,” he says, “manifest the common organic characters, but without the distinctive super-additions of true plants or animals.” Of the skeletons of the Infusoria we know little, save that they occur fossil, and are composed of silica and iron ore.

The Foraminifera are small, gelatinous animals, protected by a calcareous shell. The Sponges are said to be *ceratose* or *horny*, *siliceous* or *flinty*, and *calcareous* or *limy*, according as their frame-work partakes of these several characters.

What is said of the skeletons of the Protozoa? What of the Foraminifera?

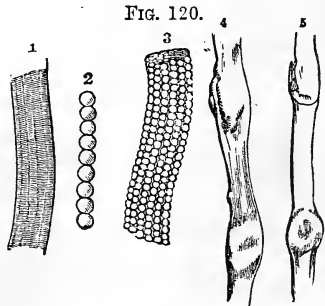
CHAPTER SECOND.

THE MOVING POWERS OF THE SYSTEM.—MYOLOGY, OR THE HISTORY OF THE MUSCLES.

DEFINITIONS AND DESCRIPTIONS.

228. Microscopic Structure of Muscle.—The Muscles, known as flesh or lean meat, compose a large part of the extremities, and the covering of the trunk. To the naked eye they appear to be fibrous, and, with the assistance of the microscope, these fibers are found to be bundles—called Fasciculi—of still smaller fibers, called Ultimate Fibers. These seem to be polygonal in form, and with an average diameter of $\frac{1}{400}$ th of an inch in man, though in some of the lower animals their size is much less.

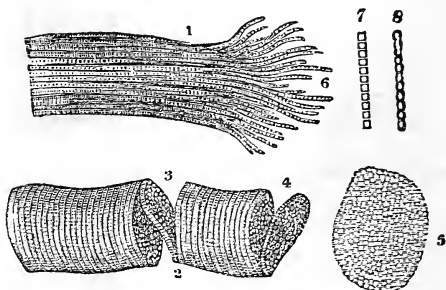
View of the stages of development of Muscular Fiber. 1, A Muscular Fiber of Animal life enclosed in its Sheath or Myolemma. 2, An Ultimate Fibril of the same. 3, A more highly magnified View of Fig. 1, showing the true nature of the Longitudinal Striæ, as well as the mode of formation of the Transverse Striæ. The Myolemma is here so thin as to permit the Ultimate Fibrils to be seen through it. 4, A Muscular Fibre of Organic life with two of its Nuclei; taken from the Urinary Bladder, and magnified 600 Diameters. 5, A Muscular Fibre of Organic life from the Stomach, magnified the same.



229. Fibrils.—The ultimate fibers are still further divisible into what are termed Fibrils. These have an average diameter of about $\frac{1}{1000}$ th

228. What is lean meat? How does muscle appear to the naked eye? What are the three microscopic elements? Describe each. 229. What is the diameter of the Fibrils?

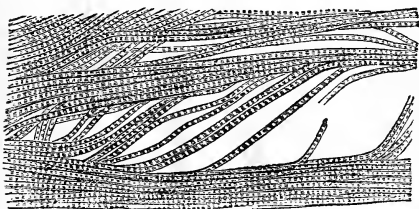
FIG. 121.



A View of the Fragments of Striped elementary Fibers, showing a cleavage in opposite directions—magnified 300 Diameters. 1, The Longitudinal Cleavage. 2, The Transverse Cleavage, the Longitudinal Lines being scarcely visible. 3, Incomplete Fracture, following the opposite surfaces of a Disc which stretches across the Interval and retains the two Fragments in connexion. The Edge and Surface of this Disc are seen to be minutely granular, the Granules corresponding in size to the thickness of the Disc and to the distance between the faint Longitudinal Lines. 4, Another Disc nearly detached. 5, A detached Disc more highly magnified, showing the Sarcoms Elements. 6, Fibrillæ separated by violence from each other at the broken end of the Fiber. 7, 8, The two appearances commonly presented by the separated single Fibrillæ; more highly magnified, at 7 the spaces are rectangular, at 8 the borders are scalloped and the spaces bead-like.

of an inch, and number about 650 in each ultimate fiber. They are unprotected by any covering, while both the fasciculus and ultimate fiber

FIG. 122.



Fibrils of Human Muscle.

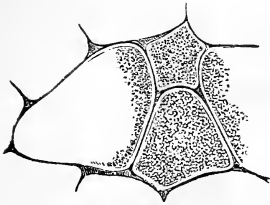
are everywhere protected by a delicate sheath called the Sarcolemma.

230. Organic, or Unstriated, and Animal, or Striped Fibers.—All the mus-

cles of the body are divided into two classes, according to their function. Those necessary for carrying on the vital functions, such as breathing and digestion, are called Organic, and those under the control of the will Animal Fibers. In addition to their use as a means of distinction, they may be known by their appearance under the micro-

What is the Sarcolemma? On what element of muscle is this wanting? 230. Give the two functional classes of the muscles.

FIG. 123.



Transverse Section of Human Fibrillæ showing a Polygonal form.

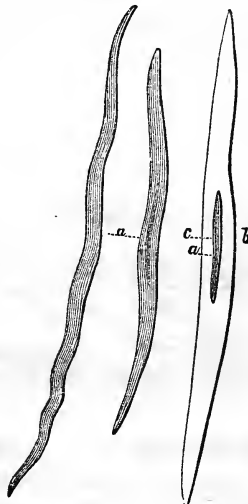
scope, the Animal Fiber being marked by transverse striæ, or stripes resembling a beaded filament, called Striped Fiber; and the Organic being made up merely of flattened bands destitute of these cross marks, and hence called Unstriped, or smooth fiber. The unstriped fibrils are developed from cylindrical or spindle-shaped nucleated cells, and are surrounded by a peculiar fluid known as muscle juice, which is unlike the plasma of the blood, since it contains casein.

FIG. 124.



A broken Muscular Fiber showing the sheath or myolemma unorn.

FIG. 125.



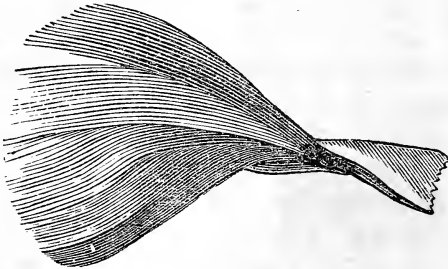
Fusiform Cells of Smooth Muscular Fiber. *a*, Two cells in their natural state. *b*, A cell treated to acetic acid, showing the nucleus *c*.

231. Tendons, Aponeuroses, Belly or Swell of the Muscle.—The extremities of the muscles are composed of dense areolar tissue in the form of tendons or cords, and that extremity which is nearest to the center of motion is called the Origin, while the one most

What is the appearance of the Animal Fibre under the microscope? Also that of the Organic? 231. State the composition of the Tendons.

remote from it is called its Insertion. These are exceedingly firm and strong, perfectly inelastic, and can not be torn from the bones without unnatural violence. If the extremity of the muscle has a large surface for attachment, its tendon is expanded into a broad membranous portion termed an Aponeurosis, as may be seen in the muscles inclosing the abdomen; while the greater portion of the muscles have a fleshy portion called the Swell or Belly, and the tendinous portion contracted into the shape of a cord, or even of a thread. In general this belly of the muscle is in a place which is the most firmly fixed, and distant from the point to be moved, in order to effect grace of motion, and beauty of form.

FIG. 126.



A Radiate Muscle.

232. Forms of Muscles.—In form the muscles present a great diversity. A Radiate Muscle (Fig. 126) is one where the fibres radiate from a central portion to distribute themselves upon a large surface. In the Fusiform (Fig. 127) the

FIG. 127.



A Fusiform Muscle.

fibres diminish in size from a center to each extremity. In

What is the fleshy portion of the muscle called? What is an Aponeurosis? Define the Origin and Insertion of a muscle. Where is the Belly of the muscle generally located?
 233. Describe the Radiate and Fusiform Muscles.

FIG. 128.



A Doubly Penniform Muscle.

the Penniform the fibres are short and arranged upon a long tendinous line, like the plumes upon the quill of a feather. The circular form, called Sphincter, is found in parts of the body where the fibres are circular, surrounding some orifice which they partially or entirely close up by their contraction. An example of this is seen around the eye and mouth. A few muscles resemble in structure a ribbon. Others a cord, and others are very thin and expanded, so that they resemble a membrane. All these forms are thus arranged to secure the greatest amount of power with dispatch, and also the most perfect freedom of motion, as well as to adapt themselves to the amount of space furnished them on the skeleton.

233. Number of Muscles, Single Muscles.—The number of muscles in man is 540, being more than twice the number of the bones. They are nearly all arranged in pairs; that is, both sides of the body have similar muscles, while the single or unmated muscles are only thirteen. Each muscle is provided with one or more antagonist muscles, or those which produce motion in an opposite direction, save a very few surface muscles about the head and neck, where the elasticity of the integuments produces the antagonistic motion.

234. Fascia.—Every muscle is covered by a firm and slightly elastic membrane called Fascia, which serves the double purpose of keeping the fibres firmly in their place, and also of producing a tonic pressure, which gives increased strength to the muscle. An illustration of the utility of this pressure is seen in the fact, that the school-boy, when engaged in running as rapidly as possible in his sports, ties a handker-

Describe the Penniform and Circular Muscles. Are there any other forms of muscles? Why are muscles of these different shapes? 233. What is the number of human muscles? How does this compare with the number of the bones? How many unmated muscles are there? What is meant by antagonist muscles? 234. What is the Fascia, and what purpose does it serve? What illustration of its use?

FIG. 129.

Anterior View of the Muscles of the Body.

1, Frontal Bellies of the Occipito-Frontalis. 2, Orbicularis Palpebrarum. 3, Levator Labii Superioris Alæque Nasi. 4, Zygomaticus Minor. 5, Zygomaticus Major. 6, Masseter. 7, Orbicularis Oris. 8, Depressor Labii Inferioris. 9, Platysma-Myoides. 10, Deltoid. 11, Pectoralis Major. 12, Axillary portion of the Latissimus Dorsi. 13, Serratus Major Anticus. 14, Biceps Flexor Cubiti. 15, Anterior Portion of the Triceps Extensor Cubiti. 16, Supinator Radii Longus. 17, Pronator Radii Teres. 18, Extensor

Carpi Radialis Longior. 19, Extensor Ossis Metacarpi Pollicis. 20, Annular Ligament. 21, Palmar Fascia. 22, Obliquus Externus Abdominis. 23, Linea Alba. 24, Tensor Vaginæ Femoris. 25, Section of the Spermatie Cord. 26, Psoas Magnus. 27, Adductor Longue. 28, Sartorius. 29, Rectus Femoris. 30, Vastus Externus. 31, Vastus Internus. 32, Tendon Patellæ. 33, Gastrocnemius. 34, Tibialis Anticus. 35, Tibia. 36, Tendons of the Extensor Communis.

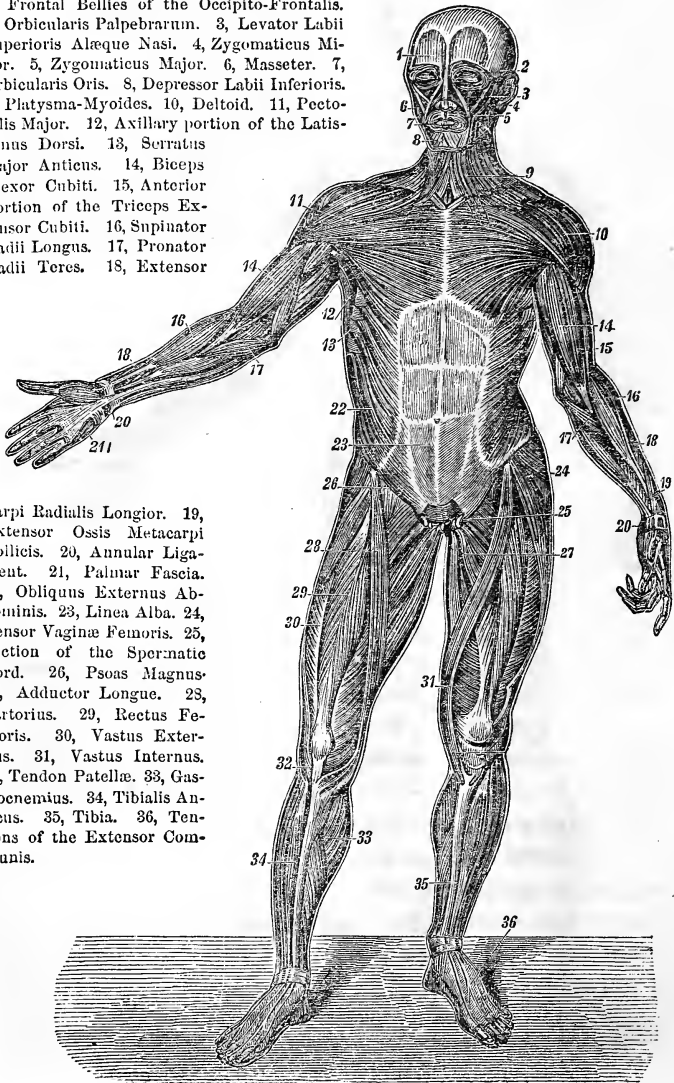
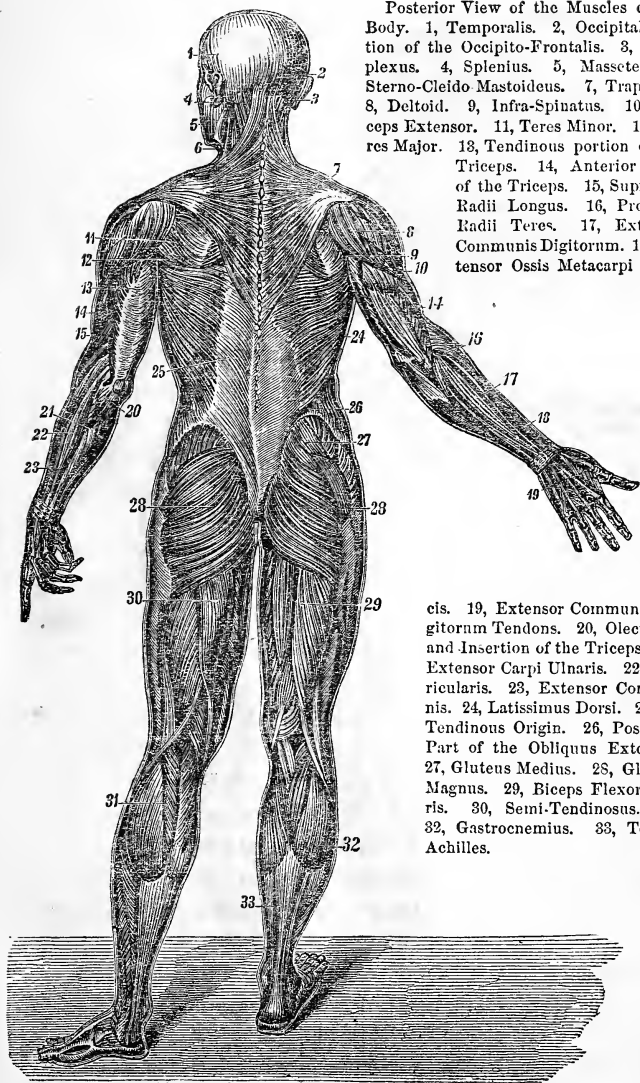


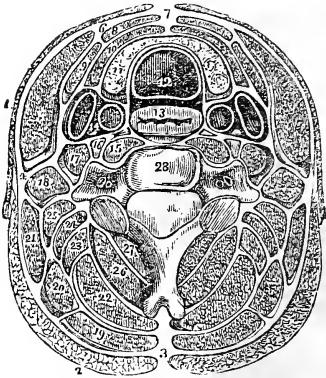
FIG. 130.

Posterior View of the Muscles of the Body. 1, Temporalis. 2, Occipital portion of the Occipito-Frontalis. 3, Complexus. 4, Splenius. 5, Masseter. 6, Sterno-Cleido-Mastoideus. 7, Trapezius. 8, Deltoid. 9, Infra-Spinatus. 10, Triceps Extensor. 11, Teres Minor. 12, Teres Major. 13, Tendinous portion of the Triceps. 14, Anterior Edge of the Triceps. 15, Supinator Radii Longus. 16, Pronator Radii Teres. 17, Extensor Communis Digitorum. 18, Extensor Ossis Metacarpi Polli-



cis. 19, Extensor Communis Digitorum Tendons. 20, Olecranon and Insertion of the Triceps. 21, Extensor Carpi Ulnaris. 22, Auricularis. 23, Extensor Communis. 24, Latissimus Dorsi. 25, Its Tendinous Origin. 26, Posterior Part of the Obliquus Externus. 27, Gluteus Medius. 28, Gluteus Magnus. 29, Biceps Flexor Cruris. 30, Semi-Tendinosus. 31, 32, Gastrocnemius. 33, Tendo-Achilles.

FIG. 131.



A Transverse Section of the Neck, showing the Fascia Profunda, and its Prolongations as Sheaths for the Muscles. 1, Platysma Myoides. 2, Trapezius. 3, Ligamentum Nuchæ. 4, Sheath of Sternocleido-Mastoid. 5, Muscle itself. 6, Point of Union of its Fascia. 7, Point of Union of the Fascia Profunda Colli of each side of the Neck. 8, Section of the Sternohyoid Muscle. 9, Section of the Omohyoid Muscle. 10, Section of the Sternothyroid Muscle. 11, Lateral Lobe of the Thyroid Gland. 12, Trachea. 13, Œsophagus. 14, Blood-vessels and Pneumogastric Nerve in their Sheath. 15, Longus Colli. 16, Rectus Anticus Major. 17, Scalenus Anticus. 18, Scalenus Medius and Posticus. 19, Splenius Capitis. 20, Splenius Colli. 21, Levator Scapula. 22, Complexus. 23, Trachelo - Mastoid. 24, Transversalis Cervicis. 25, Cervicalis Descendens. 26, Semi-spinalis Cervicis. 27, Multifidus Spinæ. 28, A Cervical Vertebra.

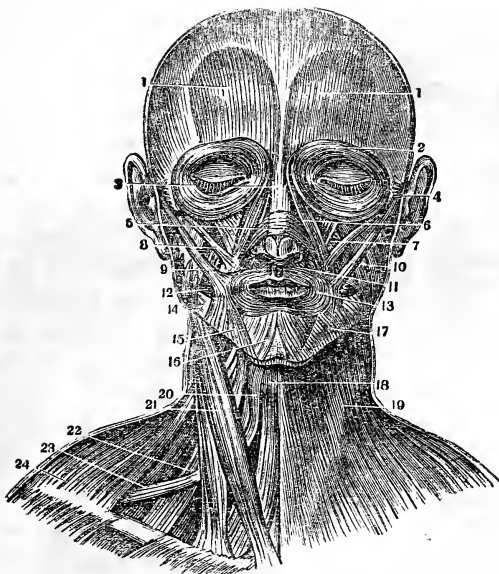
chief about his waist in order to give strength to his muscles. And so important is this membrane to the muscular system, that, upon the thigh, where very great strength and rapidity of movement is required, this membrane is thicker than in most of the other parts of the body; and not only so, but a muscle is also provided for the especial purpose of rendering this membrane very tense, when any violent action is required, or its own elasticity is insufficient.

235. Descriptions of particular Muscles.—In such a treatise as the present one, it will of course be impossible to describe all the muscles as minutely as the bones have been, nor will it be necessary; but only those which are the most interesting and instructive.

236. *Orbicularis Palpebræ*.—The muscle which surrounds the eye is a sphincter which is made of circular fibres, and when contracted closes the eye, as it is termed. Consequently this action requires the movement of no bones, and no attachment to any thing but the soft parts of the face. It is called the *Orbicularis Palpebræ*. Its antagonist is the *Levator Pal-*

What is said about the importance of this fascia upon the thigh? 236. What is the muscle that opens and closes the eye, as it is termed? What kind of a muscle is this? What is the antagonist of the *Orbicularis Palpebræ*?

FIG. 132.



A Front View of the Superficial Layer of Muscles on the Face and Neck. 1, 1, Anterior Bellies of the Occipito-Frontalis. 2, Orbicularis or Sphincter Palpebrarum. 3, Nasal Slip of Occipito-Frontalis. 4, Anterior Auriculæ. 5, Compressor Naris. 6, Levator Labii Superioris Alæque Nasi. 7, Levator Anguli Oris. 8, Zygomaticus Minor. 9, Zygomaticus Major. 10, Masseter. 11, Depressor Labii Superioris Alæque Nasi. 12, Buccinator. 13, Orbicularis Oris. 14, The denuded Surface of the Inferior Maxillary Bone. 15, Depressor Anguli Oris. 16, Depressor Labii Inferioris. 17, The portion of the Platysma Myoides that passes on to the Mouth, or the Musculus Risorius. 18, Sterno-Hyoideus. 19, Platysma-Myoides. It is wanting on the other side of the Figure. 20, Superior Belly of the Omo-Hyoideus near its insertion. 21, Sterno-Cleido-Mastoidens. 22, Scalenus Medius. 23, Inferior Belly of Omo-Hyoid. 24, Cervical Edge of the Trapezius.

pebræ, which takes its origin far back on the sides of the cavity of the orbit, and is attached to the upper lid. When contracted it opens the eye.

237. *Orbicularis Oris*.—The *Orbicularis Oris* (circular muscle of the face) by its contraction closes the mouth. Like the corresponding muscle of the eye, it has its origin and insertion in the soft parts of the face, and is made up of concen-

tric fibres. And the antagonists are those muscles which are inserted into it, coming from the different bones of the face moving the lips and nostrils, and giving much of the expression of emotion in the countenance.

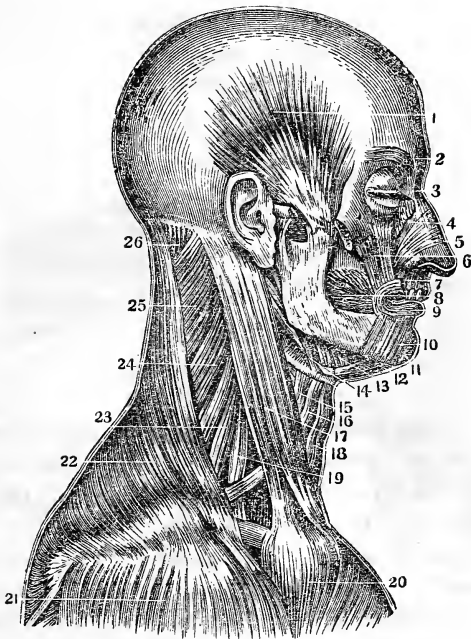
238. *Masseter and Temporal Muscles.*—The elevators of the lower jaw are two: the *Masseter* (chewing) and the *Temporal* (from the bone on which it lies). They are attached to the posterior portion of the bone near the joint, since if their position was nearer to the front part of the bone they would not contract sufficiently to bring the jaws together.

239. *Digastric Muscle.*—The lower jaw is carried downwards by the *Digastricus* (two bellies) muscle. This is a long round muscle like a cord, which commences just below the lower front teeth, and from thence runs downwards and backwards to the *os hyoides*, where it runs through a tendinous loop; after this it passes upwards and backwards to the *mastoid process* upon the *temporal bone*, just behind the ear. The contraction of this muscle then will open the mouth, when the *os hyoides* is made fast; but if the jaw be confined by its elevator muscles, the *os hyoides* will be the movable portion, and will be elevated. The necessity of such an arrangement is evident from the fact, that no muscle from the jaw to the *hyoides* would be of sufficient length to open the lower jaw by its contraction; and if it were to run backwards to the *spinal column*, the violence with which it must contract to accomplish its object, would produce such pressure upon the vessels and nerves of the neck as to injure them.

240. *Sterno-Cleido-Mastoideus.*—A bow, or bending of the head upon the *spinal column*, is effected by the action of the *Sterno-Cleido-Mastoideus* muscle (named from its attach-

What are its antagonists? What muscles aid very much in giving expression to the countenance? 238. What are the two pairs of muscles that bring the jaws together in the act of chewing? 239. State the muscle that opens the mouth. What mechanical peculiarities in its structure and operation? Why the necessity of such a complicated arrangement? 240. What is the muscle by whose action we bow the head?

FIG. 133.



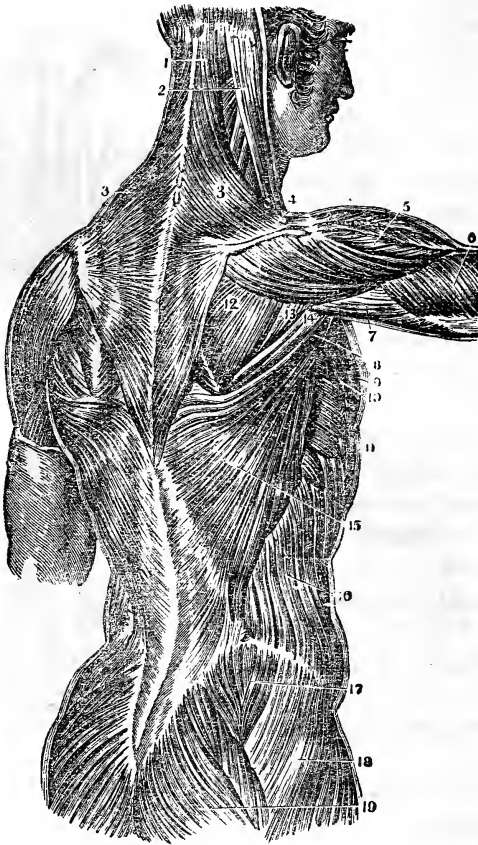
A Lateral View of the Deep-seated Layer of Muscles on the Face and Neck. 1, Temporal Muscle deprived of its Fascia. 2, Corrugator Supercilii. 3, Nasal Slip of the Occipito Frontalis. 4, Superior or Nasal Extremity of the Levator Labii Superioris Alaquo Nasi. 5, Compressor Naris. 6, Levator Anguli Oris. 7, Depressor Labii Superioris Alaquo Nasi. 8, Buccinator. 9, Orbicularis Oris. 10, Depressor Labii Inferioris. 11, Levator Labii Inferioris. 12, Anterior Belly of the Digastricus. 13, Mylo-Hyoid. 14, Stylo-Hyoid. 15, Thyro-Hyoid. 16, Upper Belly of the Omo-Hyoid. 17, Sterno-Cleido-Mastoid. 18, Sterno-Hyoid. 19, Scalenus Anticus. 20, Pectoralis Major. 21, Deltoid. 22, Trapezius. 23, Scalenus Medius. 24, Levator Scapulae and Scalenus Posticus. 25, Splenius. 26, Complexus.

ment to the Sternum, Clavicle, the Greek for which is kleis, and the mastoid process). The form of this muscle is essentially that of a thick ribbon.

241. Muscles of the Scapula.—The Scapula is covered with muscles on both sides, most of which are inserted into the head of the humerus. Their use is to rotate the hu-

What is the shape of this muscle? 241. What actions do the muscles of the scapula effect?

FIG. 134.



A View of the Muscles of the Back as shown after the removal of the Integuments. 1, Occipital Origin of the Trapezius. 2, Sterno-Cleido-Mastoideus. 3, Middle of the Trapezius. 4, Insertion of the Trapezius into the Spine of the Scapula. 5, Deltoid. 6, Second Head of the Triceps Extensor Cubiti. 7, Its Superior Portion. 8, Scapular portion of the Latissimus Dorsi. 9, Axillary Border of the Pectoralis Major. 10, Axillary Border of the Pectoralis Minor. 11, Serratus Major Anticus. 12, Infra-Spinatus. 13, Teres Minor. 14, Teres Major. 15, Middle of the Latissimus Dorsi. 16, External Oblique of the Abdomen. 17, Gluteus Medius. 18, Gluteus Minimus. 19, Gluteus Magnus. 20, Fascia Lumborum.

merus, as well as to give it protection where it articulates with the scapula, and to keep it in its place.

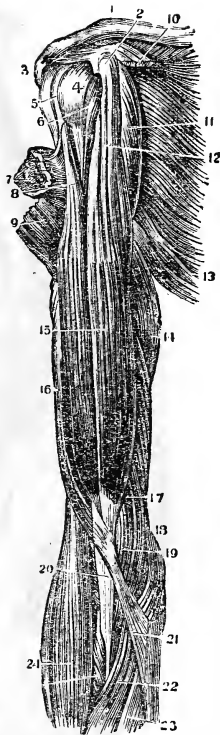
242. **Biceps.**—The Biceps (two heads, or points of attachment) is the muscle which flexes or bends the arm towards the body. It arises from the head of the humerus and scapula, and is inserted into the upper end of the radius. It is a very fine example of a fusiform muscle, and though acting at a great mechanical disadvantage as to power, it effects a rapid movement.

243. **Triceps.**—The Triceps (three heads), its antagonist, is similar in its general form, and is attached to the ulna instead of the radius. It is situated upon the posterior side of the humerus, and the force with which it may be made to contract, is seen in the powerful blow given by the boxer, or the weights raised by extending the arms upon the instrument made for the purpose in a gymnasium.

244. **Muscles of the Fore-Arm.**—The Fore-Arm is abun-

ditinous Insertion of the Pectoralis Minor. 11, Coraco-Brachialis. 12, Short Head of the Biceps. 13, Latissimus Dorsi. 14, Inner portion of the Triceps. 15, Body of the Biceps. 16, Outer portion of the Triceps. 17, Brachialis Internus. 18, Origin of the Flexor Muscles. 19, Brachialis Internus near its Insertion. 20, Tendon of the Biceps. 21, Fasciculus from the Biceps Tendon to the Fascia Brachialis. 22, Flexor Carpi Radialis. 23, Palmaris Longus. 24, Supinator Radii Longus.

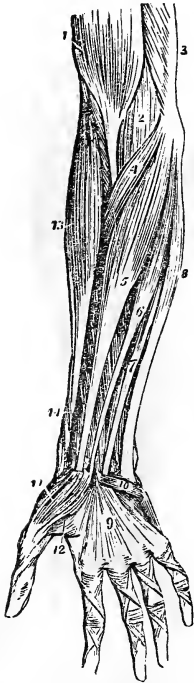
FIG. 135.



A View of the Muscles on the Front of the Arm. 1, Clavicle. 2, Coracoid Process and Origin of the Short Head of the Biceps. 3, Acromion Scapulae. 4, Head of the Os Humeri. 5, Tendon of the Biceps Muscle in the Bicipital Groove. 6, Ligamentum Adscititium dissected off. 7, Cut portion of the Pectoralis Major. 8, Long Head of the Biceps. 9, Insertion of the Deltoid. 10, Cut portion of the Ten-

242. Why is the name Biceps given to the muscle that flexes the fore-arm? What mechanical disadvantage is in its structure? What gain from it? 243. What is the antagonist of the Biceps? What actions show its mode of action?

FIG. 136.



A View of the Outer Layer of the Muscles on the Front of the Fore-Arm (Flexors). 1, Lower portion of the Biceps Flexor Cubiti. 2, Brachialis Internus. 3, Lower Internal portion of the Triceps. 4, Pronator Radii Teres. 5, Flexor Carpi Radialis. 6, Palmaris Longus. 7, Part of the Flexor Sublimis Digitorum. 8, Flexor Carpi Ulnaris. 9, Palmar Fascia. 10, Palmaris Brevis Muscle. 11, Abductor Pollicis Manus. 12, Portion of the Flexor Brevis Pollicis Manus. The Line crosses the Adductor Pollicis. 13, Supinator Pollicis. 14, Extensor Ossis Metacarpi Pollicis.

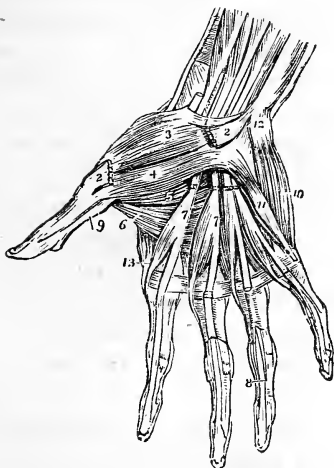
order that the fingers may be slender and easily moved, it is desirable that there should be as small a quantity of matter in

dantly supplied with muscles, many of which are fusiform in their appearance, and all of which are for the purpose of moving the hand and fingers. Most of the fibres run in a direction parallel to the bones of the fore-arm, but those which perform the actions of pronation and supination lie obliquely, and some nearly at right angles to the long muscles. In this part of the body the muscles are distinguished by slenderness of form and consequent delicateness of tendon, the latter in many cases being equal in length to the muscular fibre, since there are very few muscles below the wrist, and those only which are short and thick, for the purpose of moving the thumb and little finger.

245. Tendons of the Fingers.—The arrangement of the tendons which are attached to the phalanges, for the motion of the fingers, shows the contrivance and skill of an Infinite Being. In

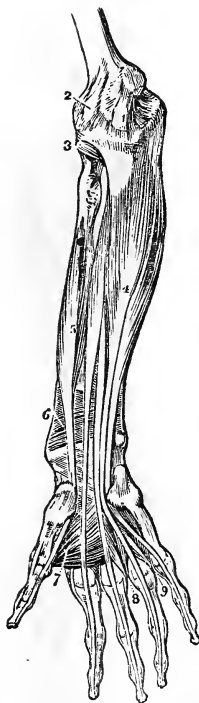
244. Give the general arrangement of muscles in the fore-arm. How do the Pronators and Supinators lie?

FIG. 137.



A View of the muscles on the Palm of the Hand. 1, Annular Ligament. 2, 2, Origin and Insertion of the Abductor Pollicis. 3, Opponens Pollicis. 4, 5, Two Bellies of the Flexor Brevis Pollicis. 6, Adductor Pollicis. 7, 7, Lumbricales arising from Tendons of the Flexor Profundus Digitorum. 8, Shows how the Tendon of the Flexor Profundus passes through the Flexor Sublimis. 9, Tendon of the Flexor Longus Pollicis. 10, Abductor Minimi Digiti. 11, Flexor Parvus Minimi Digiti. 12, Pisiform Bone. 13, First Dorsal Interosseous Muscle.

FIG. 138.



A View of the Under Layer of Muscles on the Front of the Fore-Arm (Flexors).

1, Internal Lateral Ligament of the Elbow-Joint. 2, Capsular Ligament of the Elbow-Joint. 3, Coronary Ligament of the Head of the Radius. 4, Flexor Profundus Digitorum Perforans. 5, Flexor Longus Pollicis. 6, Pronator Quadratus. 7, Adductor Pollicis Mannus. 8, Lumbricales. 9, Interossei.

them as possible. Hence, as above stated, the muscle that moves them is situated in the fore-arm, and the tendon is made as slender as possible. But here another arrangement claims our attention. A set of four tendons from a common muscle is attached to the base of the second phalanx of each finger, and a second set to the third row of phalanges. The question then arises, how can these two tendons pass upon

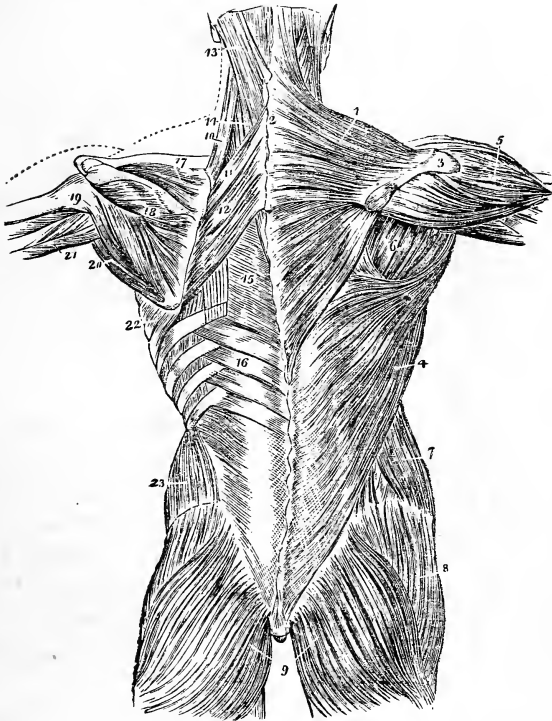
both sides (upper and lower) of the finger and be firmly enough secured to the finger to keep them in place, without making the finger of an unwieldy bulk, and at the same time allow the force to be applied upon the center of the finger rather than upon one side? The answer is this: the muscle which sends its tendons to the second phalanx lies above the other set of tendons, and where the superior tendons join the second phalanx, they are each split into two parts, through which the tendons of the lower muscle pass to the last phalanx, and move freely without interruption from the superior muscle or tendons. This arrangement is found in the foot, as well as in the hand, for giving the same motion to the toes, and very much resembles the movement of a cord through a loop.

246. *Muscles of the Thumb and Little Finger.*—The thumb and little finger, as already mentioned, are supplied with separate muscles in the body of the hand, mainly for the purpose of giving motion from side to side, as well as a partial rotation. In addition to this, there are several muscles upon the fore-arm which give their tendons only to these two extremities. The obvious use of this arrangement is to give strength and great variety of motion so necessary in the thumb and little finger.

247. *Muscles of the Back, Dorsal Muscle.*—Upon the back are found at least thirty pairs of muscles, which are arranged in six layers. These are of various forms and sizes, with complicated and obscure attachments. The main use of these muscles, taken as a group, is to keep the trunk in an upright position, and give a firm attachment for muscles to move the extremities. The outermost layer is very superficial, lying directly under the skin, while the deepest layer is deeply imbedded between different processes of the vertebræ.

Why must one tendon pass through another rather than pass along by its side? Do we find this arrangement upon both hands and feet? 246. Which two extremities of the hand have the most muscles given to them? 247. How many pairs of muscles upon the back of the body? Give the number of layers into which they may be dissected. State the essential purpose of them.

FIG. 139.



A View of the Second Layer of Muscles of the Back. 1, Trapezius. 2, A portion of the Tendonous ellipse formed by the Trapezius on both sides. 3, Spine of the Scapula. 4, Latissimus Dorsi. 5, Deltoid. 6, Infra-Spinatus and Teres Minor. 7, External Oblique of the Abdomen. 8, Gluteus Medius. 9, Gluteus Magnus of each side. 10, Levator Scapulae. 11, Rhomboideus Minor. 12, Rhomboideus Major. 13, Splenius Capitis. 14, Splenius Colli. 15, A portion of the Origin of the Latissimus Dorsi. 16, Serratus Inferior Posticus. 17, Supra-Spinatus. 18, Infra-Spinatus. 19, Teres Minor. 20, Teres Major. 21, Long Head of the Triceps Extensor Cubiti. 22, Serratus Major Anticus. 23, Internal Oblique of the Abdomen.

The largest muscle of the back (hence the name Dorsal) is of value to move the arm^s. It has its origin from the lumbar and sacral vertebræ, and the posterior third of the crest of the ilium, and is inserted by a short tendon into the upper extremity of the humerus. The action of this muscle brings

Give the origin and insertion of the Dorsal muscle. State its action.

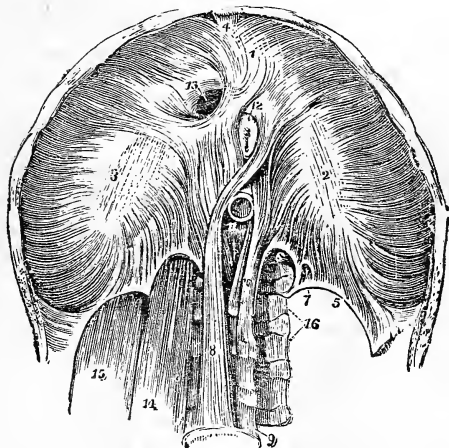
the arm downwards and backwards, as in the movements of chopping wood or striking with the blacksmith's sledge. But when the hands are made the fixed points, the body is raised upwards.

248. Superior and Inferior Serrati.—Two muscles of the back are used in forced or violent respiration. These are the Superior and Inferior Serrati Muscles. The Superior Serratus arises from the three lower cervical and two upper dorsal vertebræ, and runs downwards and forwards to be inserted into the border of the second, third, and fourth ribs. The Inferior Serratus arises from the last two dorsal and three upper lumbar vertebræ, and, running upwards and forwards, is inserted upon the four lower ribs. The name of these muscles means in Latin "saw-like," since the portions which join upon the ribs resemble the teeth of a saw. The former of these elevates the ribs, thereby enlarging the cavity of the chest, while the latter assists in its compression by depressing the ribs, and consequently the diaphragm, downwards.

249. The Diaphragm.—But the essential muscle of respiration is the Diaphragm. This, as its name implies, is a partition across the body just below the lungs,—with three large openings,—which separates the thorax from the abdomen. Its attachments in general terms may be said to be upon an oblique line drawn about the body just below the ribs, which line intersects the first lumbar vertebra, where the central tendon of the Diaphragm, as it is termed, is attached. When relaxed, it presents the appearance of an inverted and irregularly shaped cup or basin, but when in a state of contraction it becomes nearly a plane surface. Hence this muscle enlarges the chest by depressing its lower surface, thereby forming a partial vacuum.

248. Which muscles of the back are used in forced respiration? Give the origin and insertion of the two Serrate Muscles. Why called "Serrate?" 249. Give the form of the Diaphragm. What two cavities of the body does it separate? What is it an essential agent in effecting?

FIG. 140.



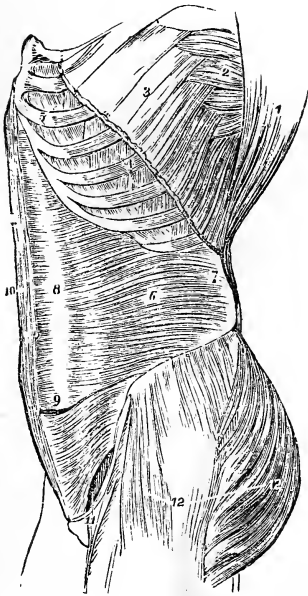
A View of the Under Side of the Diaphragm. 1, 2, 3, The Greater Muscles of the Diaphragm inserted into the Cordiform Tendon. 4, The small triangular space behind the Sternum, covered only by Serous Membrane, and through which Hernia sometimes pass. 5, Ligamentum Arcuatum of the Left Side. 6, Point of Origin of the Psoas Magnus. 7, A small Opening for the Lesser Splanchnic Nerve. 8, One of the Crura of the Diaphragm. 9, Fourth Lumbar Vertebra. 10, Another Crus or portion of the Lesser Muscle of the Diaphragm. 11, Iliatus Aorticus. 12, Foramen Œsophageum. 13, Foramen Quadratum. 14, Psoas Magnus Muscle. 15, Quadratus Lumborum.

250. Intercostal Muscles.—Between the ribs are placed two sets of muscular fibres, an external and an internal, called the Intercostal Muscles, which by their action draw the ribs upwards. The fibres run in a diagonal direction from one rib to another, so that the greatest length may be given for their contraction without compromising too much of their power. And hence we can see that while the first rib is firm and immovable, by contraction of these fibres the ribs must be raised, and by their relaxation they must be depressed. The external fibres run downwards and towards the middle line of the abdomen, while the internal run downwards and backwards.

251. Abdominal Muscles.—The principal muscles of the abdomen are large and thin expansions of muscular fibres,

250. Give the arrangement of fibres in the Intercostal Muscles. 251. What forms the principal part of the walls of the abdomen?

FIG. 141.



A Lateral View of the Muscles of the Trunk, especially on the Abdomen. 1, Latissimus Dorsi. 2, Serratus Major Anticus. 3, Upper portion of the External Oblique. 4, Two of the External Intercostal Muscles. 5, Two of the Internal Intercostal Muscles. 6, Transversalis Abdominis. 7, Fascia Lumborum. 8, Posterior part of the Sheath of the Rectus, or Anterior Aponeurosis of the Transversalis Muscle. 9, The Rectus Abdominis cut off and in its Sheath. 10, Rectus Abdominis of the Right Side. 11, Crural Arch. 12, Citeus Magnus—Medius and Tensor Vaginæ Femoris covered by the Fascia Lata.

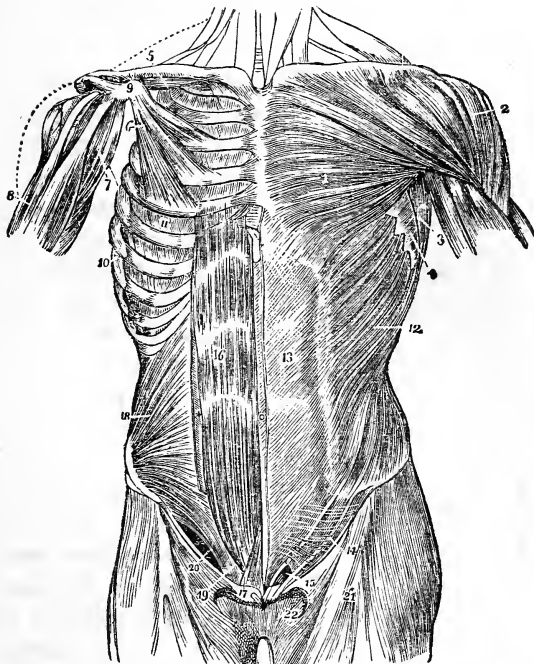
one which bends the thigh upon, or towards the trunk. It has its origin from the last dorsal and four upper lumbar vertebræ, and passes from thence downwards and forwards, gliding over the edge of the innominatum, and attaches

which completely cover the space below the border of the ribs, and above the innominatum. They are arranged under four different names, since they run in different directions as they encircle the abdomen. By their contraction they press upon the digestive organs, and thus diminish the cavity of the abdomen, and, in proportion to the elasticity of the diaphragm, the thorax also. Hence these are the essential instruments in coughing, laughing, crying, and sneezing, as well as in singing, shouting, or any action requiring expulsive effort. By their elasticity they also perform the function of expiration in natural breathing, as well as keep up a tonic pressure upon the stomach and alimentary canal.

252. Great Psoas Muscle. —The Great Psoas Muscle, known in animals as the tender loin (from the Greek signifying a loin), is the

Under how many heads are they arranged? What actions do they accomplish when contracted? 252. What is the scientific name of the "tender loin?" Give its attachments.

FIG. 142.



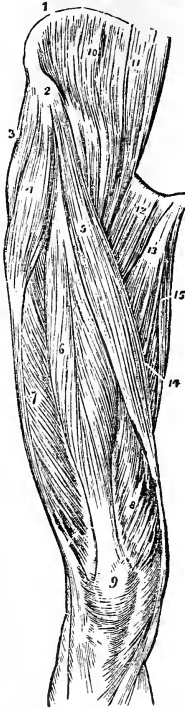
A View of the Superficial Muscles of the Left Side, and of the Deep Muscles of the Right Side, on the Front of the Trunk. 1, Pectoralis Major. 2, Deltoid. 3, Anterior Edge of Latissimus-Dorsi. 4, Serrated Edge of Serratus Major Anticus. 5, Subclavius Muscle. 6, Pectoralis Minor. 7, Coraco-Brachialis. 8, Biceps Flexor Cubiti. 9, Coracoid Process of the Scapula. 10, Serratus Major Anticus after the removal of the Obliquus Externus Abdominis. 11, External Intercostal Muscle of the Fifth Intercostal Space. 12, External Oblique of the Abdomen. 13, Its Tendon. The Median Line is the Linea Alba.—The Line to the Right of the Number is the Linea Semilunaris. 14, The portion of the Tendon of the External Oblique, known as Poupart's Ligament. 15, External Abdominal Ring. 16, Rectus Abdominis. The White Spaces are the Linea Transversæ. 17, Pyramidalis. 18, Internal Oblique of the Abdomen. 19, Common Tendon of the Internal Oblique and Transversalis. 20, Crural Arch. 21, Fascia Lata Femoris. 22, Saphenous Opening. The Crescentic Edge of the Sartorial Fascia is seen just above fig. 22, and the Interior or Pubic Point of the Crescent is known as Hey's Ligament.

itself to the front part of the lesser trochanter process of the femur. It is made up of a very compact band of fibers, and, though acting at a great mechanical disadvantage, it is capable of moving the lower extremity with great power. By

this muscle it is that the body is bent forward when the thigh is fixed, and also by its means we keep the body erect when in a sitting posture.

253. *Gluteus Muscle*.—A movement in a direction oppo-

FIG. 143.



A View of the Muscles on the Front of the Thigh. 1, Crest of the Ilium. 2, Its Anterior Superior Spinous Process. 3, *Gluteus Medius*. 4, *Tensor Vaginæ Femoris*. 5, *Sartorius*. 6, *Rectus Femoris*. 7, *Vastus Externus*. 8, *Vastus Internus*. 9, *Patella*. 10, *Iliacus Internus*. 11, *Psoas Magnus*. 12, *Pectineus*. 13, *Adductor Longus*. 14, *Adductor Magnus*. 15, *Gracilis*.

site to the last muscle, is effected by the contraction of the *Gluteus* muscle. This has its origin and insertion at points directly opposite to those of the *psaos* muscle—and forms the nates or buttock. The fibers of this muscle are the coarsest of any in the whole body, showing that they are designed for strength and not celerity of motion. Besides the movement already mentioned, this muscle is of great value when the leg is made firm by keeping the body in an upright position, or raising the body upon the thighs when it is bent forward.

254. *Muscles of the Thigh*.—The leg (*Tibia*) is moved upon the thigh (*Femur*) by the conjoint action of four muscles. These have their origin about the head of the femur, and the lower portion of the innominatum, and all unite into one tendon which is inserted upon the tubercle, or process of the

What movements are effected by it? 253. What muscle produces motion in a contrary direction to the *psaos* muscle? What is said of the size of the fibers of the *Gluteus*? 254. How many muscles act to extend the tibia or the femur?

tibia near to its upper extremity. Spoken of together, these muscles are called the *Quadriceps Extensor Femoris*. The tendon is one of the strongest in the body, and has inclosed within it the patella, which bears the same relation to the tendon as the pulley does to the cord which passes over it. The action of these muscles extends the leg, as in walking, running, or lifting the foot, and also places the femur in a line above the tibia, when the latter is made the fixed point.

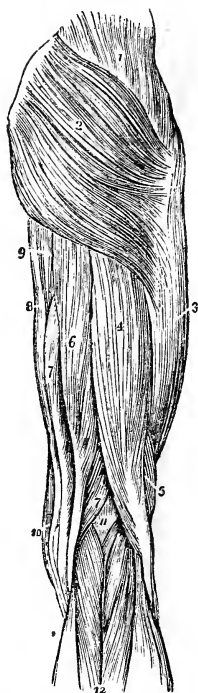
255. *Sartorius Muscle*.—The *Sartorius* or *Tailor's muscle* is a very long and slender muscle commencing at the anterior portion of the innominatum, and, descending downwards and inwards, is inserted into the upper part of the inside of the tibia. The obvious action of this muscle will be to bend the leg somewhat backwards, and then to carry it across its fellow, as is done by the tailor when seating himself for work on his bench.

256. *Tensor Vaginæ Femoris*.—A muscle already alluded to—the *Tensor Vaginæ Femoris*, or stretcher of the sheath of the thigh—arises at the upper and front portion of the innominatum, and is inserted into the very strong fasciæ of the thigh, its use being to assist the muscles in their action, by increasing the tonic pressure upon them.

257. *Muscles of the Posterior Part of the Thigh*.—The muscles found upon the posterior part of the femur and antagonizing the compound muscle in front, are four in number, taking their origin from the ischium and pubes, and being inserted into the broad head of the tibia. Their tendons make those portions of the thigh which are familiarly known as the ham-strings. Their names are the *Biceps*, *Gracilis*, *Semi-tendinosus* and *Semi-membranosus*.

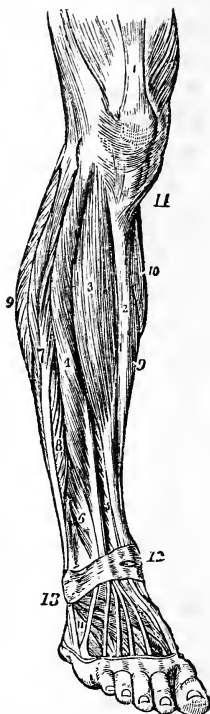
When taken together, what is the muscle called? What bone is imbedded in the tendon of the *Quadriceps Extensor Femoris*? 255. Describe the *Sartorius* or *Tailor's muscle*. 256. What is the *Tensor Vaginæ Femoris* of service for? 257. How many muscles act as antagonists to the *Quadriceps*, etc.? Give their names.

FIG. 144.



A View of the Muscles on the Back of the Thigh. 1, Gluteus Medius. 2, Gluteus Magnus. 3, Fascia Lata covering the Vastus Externus. 4, Long Head of the Biceps. 5, Short Head of the Biceps. 6, Semi-Tendinosus. 7, 7, Semi-Membranosus. 8, Gracilis. 9, Edge of the Adductor Magnus. 10, Edge of the Sartorius. 11, Popliteal Space. 12, Gastrocnemius.

FIG. 145.



A View of the Muscles on the Front of the Leg. 1, Tendon of the Quadriceps Femoris. 2, Spine of the Tibia. 3, Tibialis Anticus. 4, Extensor Communis Digitorum. 5, Extensor Proprius Pollicis. 6, Peroneus Tertius. 7, Peroneus Longus. 8, Peroneus Brevis. 9, 9, Borders of the Solens. 10, Portion of the Gastrocnemius. 11, Extensor Brevis Digitorum.

258. Muscles of the Anterior Part of the Leg.—Upon the anterior portion of the Tibia, or leg proper, are found four muscles with slender tendons, which are for the upward movement or flexion of the foot. They have their origin near the head of the tibia, and are inserted into the bones of the meta-

253. Where are the four muscles located that bend the foot upward? Give their origin and insertion.

tarsus and phalanges. Their names are the *Tibialis Anticus*, *Extensor Longus Digitorum*, *Peroneus Tertius*, and *Extensor Proprius Pollicis*.

259. **Muscles of the Posterior Part of the Leg.**—The muscles on the reverse portion of the leg are three, constituting what is known as the calf of the leg. They are the *Gastrocnemius*, *Plantaris*, and *Soleus*. They are attached to the top of the tibia on its posterior side, as well as to the lower part of the femur, and all form a conjoint tendon, the largest in the body, and which is attached to the bone of the heel. It is called the tendon of Achilles, because the great Grecian warrior is said to have been killed by the wound of an arrow at this point. The use of these muscles is to raise the body upon the toes, and are the muscles which are of the greatest value to us in the act of walking. Immediately beneath these muscles are six others which produce motion in an opposite direction to those upon the anterior portion of the leg. They are attached near the upper part of the tibia and fibula, and inserted into the metatarsal bones and the pha-

FIG. 146.



A View of the Muscles on the Back of the Leg. 1, Tendon of the Biceps. 2, Inner Hamstring Tendons. 3, Popliteal Space. 4, Gastrocnemius. 5, Soleus. 6, Tendo-Achilles. 7, Its Insertion on the Os Calcis. 8, Tendons of the Peroneus Longus and Brevis. 9, Tendons of the Tibialis Posterior and Flexor Digitorum behind the Internal Malleolus.

259. State the muscles which constitute the calf of the leg. What is Tendon of Achilles, and why is it so called? How many muscles lie deeply covered in the calf of the leg?

lances. In the tendon of one of them (*Peroneus Longus*) is found a sesamoid bone, at the point where it glides over the cuboid bone.

260. *Muscles of the Foot.*—A few muscles are found upon the upper and under surface of the foot, most of which

FIG. 147.



A View of the Muscles on the Sole of the Foot immediately under the Plantar Fascia. 1, *Os Calcis*. 2, Section of the *Fascia Plantaris*. 3, *Abductor Pollicis*. 4, *Abductor Minimi Digiti*. 5, *Flexor Brevis Digitorum*. 6, Tendon of the *Flexor Longus Pollicis*. 7, 7, *Lumbricales*.

their tendons would extend in a straight line from the upper part of the tibia to the last phalanx, thus making the leg and foot very cumbersome and unwieldy organs, and poorly adapted to their present use.

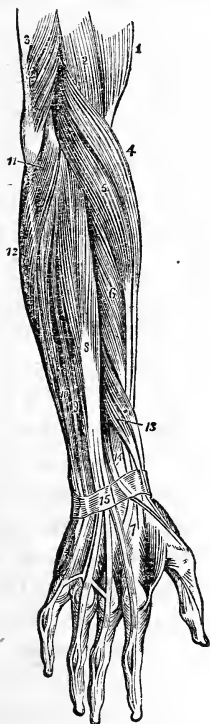
arise near the tarsus, and are inserted at the base of the phalanges. In their action the toes are either bent or extended.

261. *Annular Ligaments.*

—An interesting contrivance for preserving the slenderness of the hand and foot is found in the *Annular Ligaments*. These are large bundles of ligamentous tissue which pass around the wrist and ankle, very much resembling a bracelet. (Figs. 148, and 149, p. 133.) They are very firm and stout, and their design is to keep in place the tendons which move the extremities. When, for example, we move the toes upwards, the muscles which effect this motion with

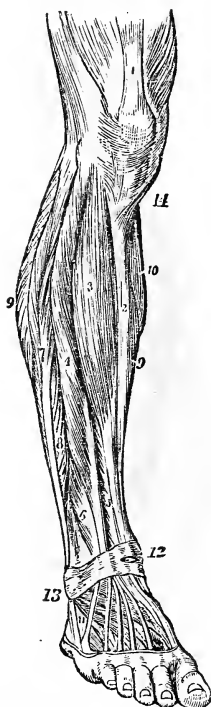
261. What is the use of the *Annular Ligaments*? What ornaments do they very closely resemble? Suppose these or their equivalent was wanting?

FIG. 148.



A View of the Outer Layer of Muscles on the Back of the Fore-Arm (Extensors). 1, Lower portion of the Biceps Flexor. 2, Part of the Brachialis Internus. 3, Lower part of the Triceps Extensor. 4, Supinator Radii Longus. 5, Extensor Carpi Radialis Longior. 6, Extensor Carpi Radialis Brevis. 7, Tendinous Insertions of these two Muscles. 8, Extensor Communis Digitorum. 9, Portion of the Extensor Communis Digitorum called Auricularis. 10, Extensor Carpi Ulnaris. 11, Anconeus. 12, Portion of the Flexor Carpi Ulnaris. 13, Extensor Minor Pollicis. The Muscle nearest the Figure is the Extensor Ossis Metacarpi Pollicis. 14, Extensor Major Pollicis. 17, Posterior Annular Ligament. The distribution of the Tendons of the Extensor Communis is seen on the backs of the Fingers.

FIG. 149.



A View of the Muscles on the Front of the Leg. 1, Tendon of the Quadriceps Femoris. 2, Spine of the Tibia. 3, Tibialis Anticus. 4, Extensor Communis Digitorum. 5, Extensor Proprius Pollicis. 6, Peroneus Tertius. 7, Peroneus Longus. 8, Peroneus Brevis. 9, 9, Borders of the Soleus. 10, Portion of the Gastrocnemius. 11, Extensor Brevis Digitorum.

FUNCTIONS OF THE MUSCLES.

262. Irritability of Muscular Fiber.—Muscular fiber has one characteristic peculiar to this tissue. This is known as Irritability or Myotility, the shortening of the fiber when a stimulus is applied. The stimulus may be mechanical, as when the legs of a grasshopper are irritated with a probe or some pointed instrument, it produces contractions. Electric and galvanic currents, also, when made to pass interruptedly through any muscular portions of the body produce contractions; as when a person grasps the handles of an electro-tome or seizes the ball of a Leyden jar. And lastly, vitality is a muscular stimulus.

FIG. 150.



Structure of the Fibrillæ. *a*, A fibril in the state of ordinary relaxation. *b*, A fibril partially contracted.

263. Condition of the Fibrils in a State of Contraction.—Formerly it was supposed that muscular contractions were due to a zig-zag position which was assumed by the fibrils; but macroscopical examination has proved that the shortening of the fiber is owing to a change in the diameter of the ultimate fibrils; the cell in the fibril at rest having its longest diameter parallel to the fiber, while in a state of contraction the longest diameter is at right angles to this.

264. Tonicity.—Another characteristic of muscular fiber is Tonicity. This is a constant strain or stretch of the muscular fiber, while irritability or contractility only manifests itself when a stimulus is applied. This is a property which is exhibited when a bone is broken or some muscular fibers are separated. Thus, when a cut is made

262. What is the prominent characteristic of muscular tissue? Illustrate the mechanical, electric, and vital stimuli. 263. How do the cells of the fibrils arrange themselves during a contracted state? 264. What is understood by Muscular Tonicity? When is this only manifest?

directly across the fibers the gash at once opens very widely ; or if a bone is broken and the ends allowed to slide by each other, it is only by great force that they can be brought back to their proper places. The value of this property is seen in keeping the muscles in a state ready for action, as well as in assisting the ligaments to keep the joints firmly together.

265. *Dependent on Vital Energy.*—Both of these characteristics are dependent upon nervous or vital energy. For if life be extinct, or the nerve proceeding to any muscle be cut off, tonicity and irritability soon cease ; although they remain for a longer time in the involuntary than the voluntary muscles. As, for example, the heart of a sturgeon, after its removal from the body, has been known not only to pulsate for a short time, but even to keep up its action until its folds fairly rustled from inherent dryness.

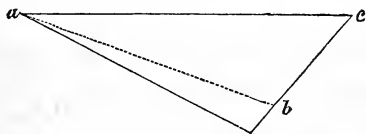
266. *Muscular Waste the Cause of Muscular Contraction.*—But here the question meets us, What is this power that passes through the nerves to each fibril, and how does it energize the muscle ? Is it a fluid acting on the fibers in the same manner that water acts upon the strands of a rope, or is it an imponderable agency, like electricity or heat, passing through the nerve by polar attraction or conduction from particle to particle ? At present we must rest with the facts of muscular movement, and perhaps we can never solve the mystery in this world. The nature of what we vaguely denominate nervous or vital force has never been determined. No mystery in religion exceeds that of muscular movement. It however seems to be the case that muscular contraction is in a good degree dependent on a due degree of arterialization of the blood ; for if a muscle be placed in carbonic acid its irritability soon ceases, while in oxygen it remains a long time after it is removed from the body. A want of the proper amount of oxy-

Of what use is this property ? 265. Upon what do both myotility and tonicity depend ? In which muscles do they remain the longest after death ? Instance the heart of the sturgeon. 266. What is all we know of the power that produces this contraction ?

gen is the cause of the inability to exertion experienced in the thin air of mountain tops and the relaxation of the muscles in fainting from exposure to carbonic acid, ether, or chloroform. On the other hand, the more full the respiration, the more energetic the muscular power. The effect of oxygen upon the tissues is that of waste, or a consumer; that is, it produces a more rapid circulation of matter by removing the carbonic acid, and substituting itself in its place; and the deeper the respiration, the more energetically will all the functions of the body be carried on. Hence a plausible theory offers itself to explain the cause of muscular contraction, which is, that "muscular contraction is the necessary physical result of muscular disintegration."

267. The Mechanical Disadvantage at which many Muscles Act — The Reason of it.—The force of muscular contractions is almost always very great, sometimes so powerful that some of the fibers are ruptured. But the main evidence of this great force is exhibited in the mechanical disadvantage at which most of the muscles act. For instance,

FIG. 151.



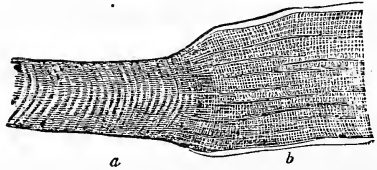
if the muscles were attached at *c*, a much greater weight could be lifted by the expenditure of the same power than if it were

attached at *b*; but a much longer portion of time would be necessary to produce contraction in such a length of fiber, *a c*, than in a shorter portion, *a b*. Besides, in most cases it would be quite impossible for the muscles to contract sufficiently to effect what they now do, since muscular fiber can not shorten itself more than one third of its whole length, as measured when uncontracted, or in a state of rest.

What, however, do we know about deficiency of oxygen as affecting these properties? Instance ether and chloroform also. What hypothesis has been suggested owing to the waste produced by oxygen? 267. How is muscular power well illustrated? What loss and what gain are both experienced by this construction?

268. Contraction commences at one End—Only a Part of the Fibrils in a State of Contraction at Once.—The contraction of a muscle does not take place in all parts of the fibers at the same time, but commences at one end, and continues through in regular order, as is seen in the cut 152. It is also seldom the case that all the fibers are contracted at once. This explains the reason why insane people are often so prodigiously strong, since the whole of the muscle is made to act at once. It also shows us why we can keep a muscle contracted for a long time, as in carrying a weight for a long distance, and also why a short and violent muscular action weakens and tires us more than a protracted and more moderate one. The simple explanation is, that but a part of the fibrils are contracted at once, and when the nervous force is exhausted from one set of fibrils, a new set are called into action to supply their power.

FIG. 152.

Muscular Fiber contracting. *a*, Uncontracted part. *b*, Contracted part.

269. Examples of Muscular Strength.—As examples of great muscular strength, we have given to us the history of a Samson and Goliath. And in more modern times we read of Milo of Crete who killed an ox with his fist, and then carried it more than 600 feet. He also saved the life of his fellow-scholars and teacher, Pythagoras, by supporting the falling roof until they had time to escape. Another man is mentioned who could raise 300 pounds by the muscles of his lower jaw. This strength, however, is exhibited much more strikingly in another part of this chapter under the head of Comparative Myology.

268. Do all the fibers, or even all portions of each fiber act at once in ordinary cases? Instance insane people. 269. Give examples of great muscular strength as illustrated by Goliath and Milo.

270. Rapidity of Muscular Contraction.—The rapidity of muscular movement is equally wonderful. The pulsations of the heart in children can often be counted as high as 200 per minute. Some persons can pronounce 1500 letters in a minute (of course combined in words), each one requiring the contraction and relaxation of one or more muscles, and both occupying $\frac{1}{3000}$ th of a minute, or $\frac{1}{5}$ th of a second. The muscles, too, which move the wings of some insects must contract many thousands of times every second in order to produce the musical tone or humming that is frequently heard when their wings are in motion.

271. Duration of Muscular Contraction—Intrinsic and Available Force—Shortening of Muscular Fiber—Muscular Sense—Sound and Heat.—The length of time which muscles may be on the stretch is astonishing, but especially so among the lower orders of animals soon to be mentioned.

The intrinsic force of a muscle is no measure of its available power. Thus the deltoid, if able to act in a perpendicular direction, would raise 1000 pounds; while, acting at the great mechanical disadvantage (that it does) of passing over the head of the humerus, it can not lift 50 pounds held in the hand.

The amount of shortening of the fiber in muscular contraction is differently stated by physiologists. The statements are from one third to one sixth the length of the muscle. That is, a muscle three inches long can by contraction become only two inches, or one six inches long become five inches. It is probable, however, that the former statement is the nearest to the truth, and that a muscle is shortened from one half to one third its original length.

The muscles give but little evidence of sensibility; that is, perception of objects by pressure or touch; but when fatigued or overworked, they give a painful sensation, and also give to their

270. State instances of great rapidity of muscular movement, as in pulsations of children's hearts and the power of articulating words. 271. State the distinction between the intrinsic and available force of muscles. How much does muscular fiber shorten during its contraction? What is muscular sense?

possessor a very delicate sense of the amount of their contractions.

It is also an established fact that a peculiar rumbling sound is given off and heat evolved during muscular contraction, the latter of which is easily explained by the increased muscular waste, or the absorption of oxygen and evolution of carbonic acid.

272. Precision of Muscular Contraction.—An astonishing precision in contraction of muscles is seen in those of the human larynx. The largest of these muscles is less than three fourths of an inch, and the total amount of contraction one fifth. And since the ordinary compass of the human voice is two octaves, or twenty-four semi-tones, and ten intervals between each of the contiguous semi-tones can be easily detected by a person with a cultivated ear, there must be a shortening of only $\frac{1}{25}$ th of an inch. And more wonderful than all is the precision and readiness with which an ordinary singer can accurately strike one note after another with intervals of from two to twenty-four semi-tones.

HYGIENIC INFERENCES.

273.—1. Muscles need Use.—The muscles should be used. This is necessary to stimulate the blood-vessels and lymphatics to a healthy action, so that the nutritious particles may be deposited in proper proportion, and the waste particles be removed; in other words, to promote that constant change which in all the organs of the body is so necessary for health. Their moderate use also promotes their growth and strength, while inaction causes them to diminish both in strength and size.

Speak of sound and heat attendant upon muscular contraction. 272. What remarkable precision is there in many muscular movements? 273. Why is it necessary that the muscles be used to a moderate extent?

274.—2. *Muscles need Rest.*—The muscles also need rest. That is, after work they need repose to restore the energies which they have expended, and if the amount of rest which they receive is not sufficient to recruit the strength, they will soon become small and weak; for the lymphatics are so stimulated that the amount of matter removed exceeds what is deposited. But sleep is the grand restorative after severe muscular exertion; this alone gives back to the muscle its life and strength.

275.—3. *Muscles should Rest gradually after Violent Exercise.*—Experience, however, shows that when the muscular system has been exercised vigorously it should not be allowed perfect rest at once, but by degrees. Such a course would save many an ache and stiff joint to the hard-working farmer and mechanic, and especially to the one who labors till the body is in a state of perspiration.

276.—4. *Muscles require Regular Exercise.*—Labor or exercise that is regular and uniform is much the most conducive to health. The muscles will endure a much greater amount of effort if made steadily, rather than spasmodically. Regularity of action is important in every function, but in none more evidently so than the muscles.

277.—5. *Especial want of Exercise by Students and Sedentary People.*—We see that students and other sedentary persons are in special need of physical exercise, and should consider it a moral duty to secure it, for it stimulates every organ to a healthy action. The blood flows more readily, and more completely fills all the minute vessels; the glands of the skin act more vigorously; the lymphatics and nutritive vessels perform their part more perfectly; and even the nervous system is kept in a healthy state by exercise. It is best, however, to get exercise if possible with some other

274. For what do the muscles of hard-working men need rest, and especially sleep? 275. Is it always best to gain rest at once, or gradually? 276. What kind of labor or exercise is most conducive to health? 277. Why do students and sedentary people stand greatly in need of muscular exertion? Is mere drudge work the best exercise?

motive than a mere conviction of its necessity and importance. For if we are interested in pursuing an object, the mind acquires a healthy action, and by its reaction brings on a state of perspiration in the body. In this case we have obtained two ends, the muscular system has been exercised, and the mind has gained full recreation from study. Hence the study of natural history, and especially those branches of it which require field exercise in collecting specimens, not only strengthens the mind and furnishes new objects of thought, but is an admirable method of gaining bodily strength.

278.—6. Value of *Gymnasia*, etc., to Colleges and Academies.—We see how injurious to health is the stimulating plan adopted in too many of our higher seminaries of learning. The mind is crowded to its utmost with labor; too much time is taken up with cultivating the intellect, while the body is left to take care of itself. A gymnasium or some equivalent means of taking exercise is as important a thing to our colleges and academies as are the buildings, libraries and cabinets themselves. And may it not be the reason why literary men are generally so great sufferers from ill health, that so little attention is paid to physical culture during the preparatory and collegiate course? Is it not poor economy to take so much pains to cultivate the inhabitant, when the house that it is to live in is such a miserable tenement, and receives so little care and improvement?

REMARKS UPON MUSCULAR DEVELOPMENT.

With the existing customs of the wealthier classes of society, and our higher seminaries of learning especially, it is hardly possible to say too much upon the necessity of physical education: not that it is best to lower the standard of intel-

Why does the study of some branch of natural history secure the best exercise? 278.
What is said of the effect of a neglect of muscular exercise in schools and upon many educated men of our country?

lectual culture in the least, or to dictate how those who are possessed of an abundance of wealth shall dispose of it, but simply to say that a thorough physical education is essential for a proper enjoyment and improvement of our whole nature, body, mind, and soul. The evils of a neglect of this branch of education exhibit themselves, not only in puny clergymen and lawyers, but in the meager and attenuated physiques of our mothers and sisters.

Boys, especially *when* boys, will run, jump, shout, and be in the open air in spite of any thing but the closest watch; in fact it is thought proper that boys should be ruddy in countenance and healthy, but with girls it is not so. By grossly perverted usages of society, it is considered *improper* for girls to run and jump and shout, and especially so out of doors; but while mere children even, they must act as *young ladies*, and never move except in a precise and measured manner, often as unnatural as it is injurious; and any thing that requires muscular effort, is regarded as vulgar, and of course not to be undertaken. Now, physiology tells us that just the thing which our girls and ladies stand in need of at the present day is active, vigorous muscular effort, such as walking, rowing, riding on horse-back, and calisthenic and gymnastic exercises. And let the question be suggested to parents, guardians, and in fact all interested in the prosperity or even the existence of the Anglo-Saxon race on this continent, whether the physical development of ladies shall be neglected through the idle whim of its *impropriety* (which often only generates a false modesty or prudishness), and thus tend to a deterioration of the race which is now in fearful progress in the United States.

Without a proper exercise of the muscles in man or woman, all the other portions of the body must suffer, and if so, why, through an over sensitive, prudish caution, must woman be the unfortunate victim? The old Greeks—heathen though they were—did not neglect the development

of the body in either men or women. And while they most thoroughly disciplined the intellectual powers, their "seminary of learning" was the gymnasium, where, as prominent characteristics, were the running, wrestling, and boxing exercises, and by them regarded as equally important with intellectual effort.

But though the neglect of muscular exercise is the most sadly evident in the female portion of society, yet it is not confined here. For many of our educated men are of feeble physical culture, mainly because of the cultivation of the intellect at the expense of the body. Most men in the academical and professional schools are apt to regard study as first and foremost, and a care of the body afterwards—*if there be any time for it!* How many make it a duty—and a religious one too—to take all the time that can possibly be secured for study, and leave the exercise as a thing desirable but not essential! But we maintain that a system of education which simply crowds the mind with discipline, to the neglect of physical culture, is not only a defective, but a monstrosly pernicious system. Students may bear the cramming process through the academical, collegiate, and even professional course, but sooner or later the body will be overpowered. Nature's laws cannot be violated without suffering the penalty at some time; and of what service can the most cultivated minds become, if the body is too feeble to use their learning? Of what beauty is the most brilliant gem without the art of the lapidary to develop and exhibit its splendor?

In how few educational institutions in our country is there any thing like a system of exercise suggested, or much more required? In how few of them does muscular development meet with any thing but discouragement?

It is true that muscular development has for too long a time among us been associated with the lower class of people, as prize-fighters, shoulder-hitters, bruisers and horse-racers, in all which cases it should meet a decided disapproval. But is

this a natural tendency of physical development? Is it necessary that a well-developed man must of necessity be a brutal fighter? or that a beautiful horse must necessarily lead his master to expose him to cruel excesses to test his speed? If we do adopt the principle that physical development has such an immoral tendency, is there any culture of body or mind that we shall not be compelled to resign to the great tempter, since he can so sadly pervert every thing?

Ought not then a gymnasium or some equivalent means of physical culture, to be attached to all our educational institutions (female as well as male), as well as models, libraries, cabinets, and apparatus? And if so, why should there not be regular trainings of the body required by instructors as well as mental exercises? And since but a small portion of time is required for physical exercise if it be vigorous, as it will of necessity be in a gymnasium, why may not a portion of school duties each day be a half hour or an hour of exercise in the gymnasium morning and evening? Does not every practical teacher see that at least this would relieve the necessity of a great many excuses, such as for "head-ache," "feel sick," "unable to study to-day," etc.

FIG. 153.



There are, however, many simple gymnastic exercises which may be indulged in by everybody, boys and girls, men and women, without an outlay of any thing except a few dimes, and the use of a few yards of space anywhere on terra firma.

From a piece of inch pine board from two to four feet long (depending on the size of the person to use it), and three to six inches wide, let an instrument be made called the *back board*, as is shown in Fig. 153. With this simple piece of apparatus grasped at each end, as in Fig. 154, a great variety of exercises can be invented by any one, which will soon set the whole surface in perspiration, and if persevered in will, in the course of several days, impart pliancy and strength to the muscles.

FIG. 154.



A more vigorous exercise can be obtained by using what is termed the "Indian club," or "scepter," one in each hand. (See Fig. 155.) These may be made by the commonest turner from any sort of wood, and it is well that there be several pairs of them, differing in weight and length, and loaded with lead if necessary, adapted to the age and muscular development of those using them. And it is astonishing what great strength of muscle can be acquired by this means of exercise continued through a few weeks. Some



of the different exercises which may be performed with this club may be seen in Fig. 156, p. 146.

Another simple mechanism for gaining physical exercise, called the "triangle," is seen in Figs. 157 and 158. It is

FIG. 157.

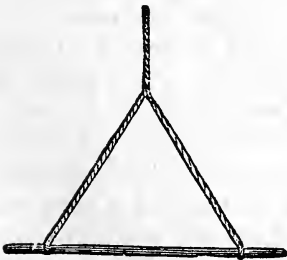


FIG. 158.



FIG. 156.

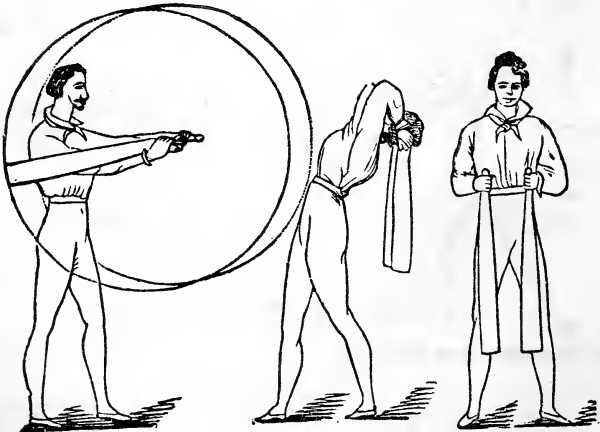
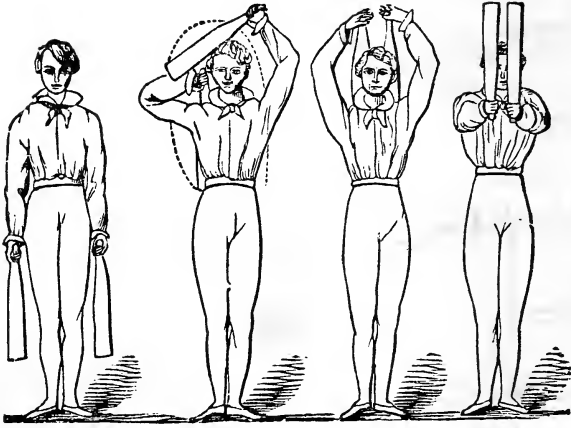
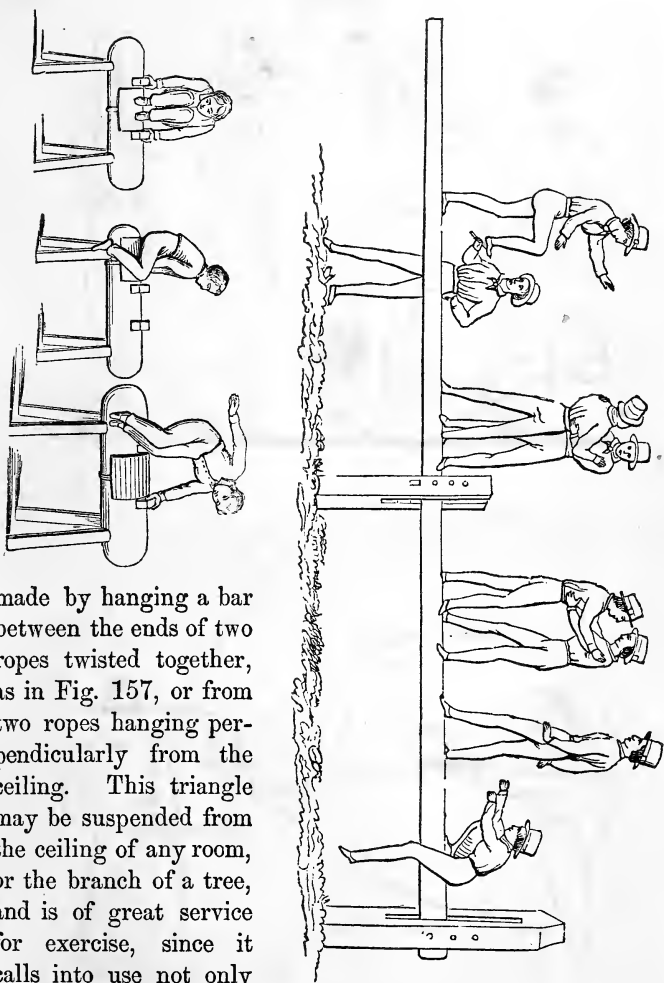


FIG. 159.



made by hanging a bar between the ends of two ropes twisted together, as in Fig. 157, or from two ropes hanging perpendicularly from the ceiling. This triangle may be suspended from the ceiling of any room, or the branch of a tree, and is of great service for exercise, since it calls into use not only the upper, but also the lower extremities.

But much more complete exercise, and that which tends to give symmetry of form to either sex, may be obtained from

FIG. 160.

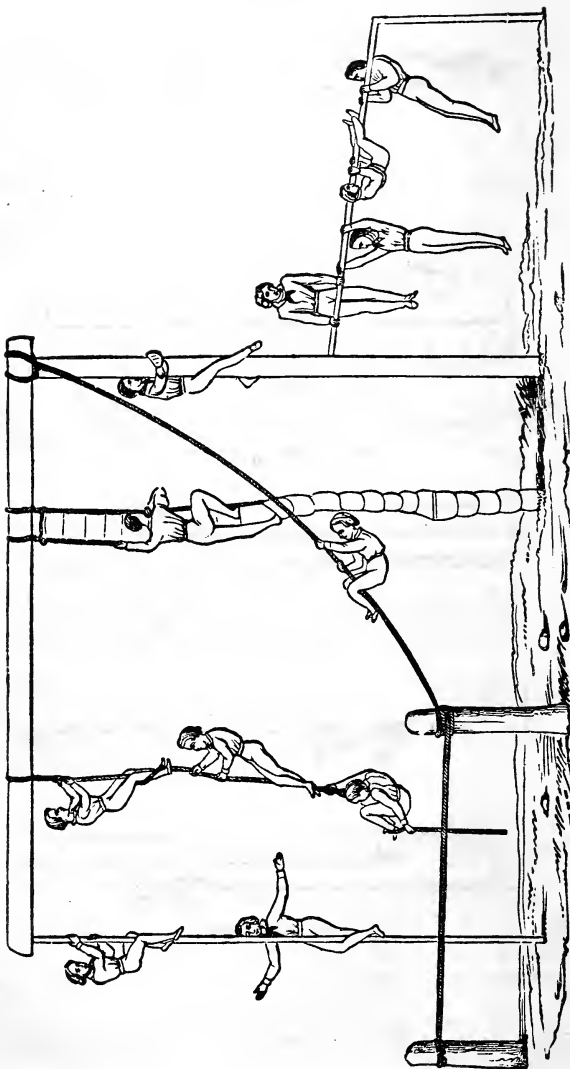
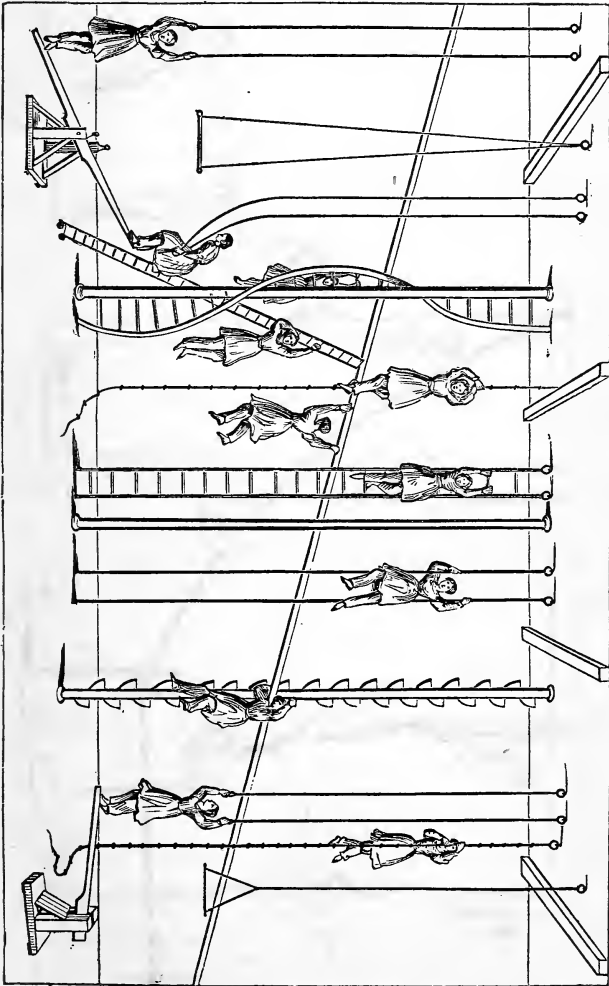


FIG. 161.



the various appurtenances of the gymnasium. Here, by means of bars, ladders, ropes and similar pieces of apparatus are the best arranged contrivances, not only for a general exercise of the whole body, but for developing the most important muscles. A few pieces of this kind of furniture may be seen in Figures 159, 160, and 161. These may be fitted up in any large and unfurnished building, since the essential requisites are a few solid timbers to give firm support to the bars and ladders, and walls mainly to protect from exposure to severity of weather.

The exercise of rowing is one which probably can not be surpassed as a means of exercise, since it not only requires a use of the muscles, but is exhilarating and recreating to the spirits; and where circumstances admit, whether as supplementary to or in place of a gymnasium, we would say by all means let both boys and men, and ladies too, indulge in the invigorating and healthful exercise of boat rowing.

COMPARATIVE MYOLOGY.

279. In microscopic structure the muscles of the lower orders of animals very closely resemble those of man, as may be seen in the fibrils of the pig, Fig. 162.

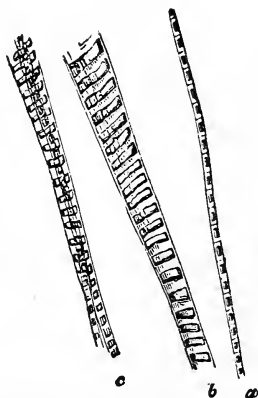
280. Tegumentary Muscle—Abdominal Muscles—Muscles of Lower Jaw—Diaphragm.—The general structure and relations of the muscles in quadrupeds differ very little from those of man save in the extremities. Nearly all quadrupeds have a set of fibers called the Tegumentary Muscle, which is a thin layer of muscle lying just beneath the skin, and which is only rudimentary in man. Its function is to contract and corrugate the skin in order to remove dust, insects, or any offending matter, as can be seen in a

279. What is said of the structure of muscles in all mammals? 280. Describe the Tegumentary Muscle.

horse or cow during the time when flies irritate by biting. The same muscle in the porcupine and armadillo is made use of to roll themselves up in a ball. In apes the foot and hand are similar both in muscular development and function, but are by no means equal to the hand of man. The abdominal muscles of all quadrupeds are stronger than man's, since from their position the weight of the viscera is thrown upon the muscular walls of the abdomen, and

not upon the bones of the pelvis, as in him. In beasts of prey the masseter and temporal muscles are more strongly developed than in man, because great strength is required in the jaw to secure the food and fit it for digestion. In all mammals a more or less complete diaphragm is found, though it is absent in nearly all the remaining vertebrata.

FIG. 162.



Muscular Fibrils of the Pig. *a*, An apparently single fibril. *b c*, Collections of fibrils.

281. *Muscles of Birds—Ossification of Tendons.*—The muscles of most birds are remarkable for their deep red color and the density of their structure. In herbivorous ones, however, they are of a paler color and softer in texture, and hence more palatable as articles of food. The bellies of the muscles are for the most part situated on the body, so that they may not encumber the limbs; and those designed to move the extremities are extended into long tendons, which, as already mentioned, become ossified to a considerable extent.

Of what use is this muscle in the porcupine and armadillo? Why are the abdominal muscles of quadrupeds proportionally stronger than in man? What is said of the strength of the masseter and temporal muscles of beasts of prey? What of a diaphragm? 251. What are the muscles of birds remarkable for? What is said of the tendons and bellies of muscles in birds?

282. *Suspensory Muscle.*—In the turkey and birds of like character an especial muscle is provided for the support of the crop, which so often becomes heavily loaded with food.

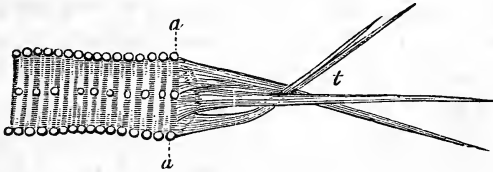
283. *Muscles of Birds' Feathers—Their Use—Their Number—Muscles of the Breast.*—Birds are supplied with tegumentary muscles somewhat after the manner of quadrupeds. The main difference is, that in birds a few muscular fibers are sent to each quill feather of the body, by which the feathers can be violently shaken to dislodge dirt, or they may be merely raised on end by the same muscles. This property is well seen in common barn fowls, when they shake themselves after having lain in dry dirt. A hen with a brood of chickens, too, when disturbed shows her wish to protect her young by ruffling up her feathers and attacking whoever may annoy her. In some birds, where there are 3,000 quill feathers, the number of muscles must be at least 12,000. No muscles are found upon the face of birds, but to secure the degree of motion to which the head is subject, and the flexibility of the neck, the muscles of this portion of the body are very strongly developed. The most powerful muscles of birds are the pectoral, or those on the breast; one end of which is attached to the keel of the sternum and the other to the humerus. These muscles are three in number on each side, and the largest one exceeds in weight all the other muscles of the body.

284. *Muscles of Fishes.*—The muscles of fishes are characterized by their slight degree of separation from one another, by the absence of long tendons, and the softness of their fibers. Their color is generally white, or yellowish white, but in microscopic structure they do not differ from those of the other vertebrata. By far the largest part of the fleshy

282. What peculiar muscle is found in birds like the turkey? 283. What is worthy of note in the tegumentary muscle of birds? In what condition does a hen show the action of the tegumentary muscles? What number are there in some birds? Why is there need of so few muscles on the head of birds? Upon what portion of the body are there the most muscles? Give the actual amount by weight. 284. What is the peculiar feature of the muscle of fishes? Give their color.

mass of these animals is made up of the lateral muscles of the body which extend from the head to the caudal fin; and as each lateral muscle by its contraction bends the body to its own side, the motion of the fish through the water is effected in the same manner as the oarsman sculls his boat.

FIG. 163.

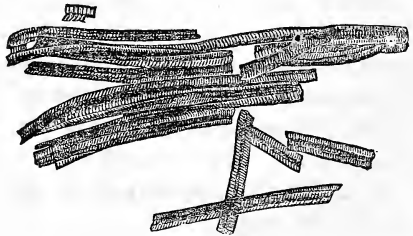


Muscular Fiber from Leg of Meat Fly. *a*, Termination of Muscular Fiber. *t*, Tendon.

285. **Muscles and Locomotive Organs of the Invertebrates.**—Muscles, both striated and smooth, voluntary and organic, abound in all the invertebrates. They are modified in form and position to meet the wants of the animal as wisely as in the higher tribes.

In some of the Polypi movements are made by the contraction of their sides, in which no muscular fibres have been discovered, though existing in other parts of the animal. The muscles of insects are either colorless or of a dirty yellow.

FIG. 164.



Insect Fasciculi Magnified Fifty Diameters.

286. A great variety of locomotive organs are found in the Invertebrates. The Echinoderms have tentacles, called Ambulacra, on some of which there are suckers, which enable them to hold on to substances. They have also forcep-like organs of locomotion. Most of the acephalous molluscs move by a highly developed foot, which, in the Cephalopoda, is used as a sucker. The Cephalopods have arms with suckers at-

What portion of the body is made up of them? 236. What are the locomotive organs of Invertebrates?

tached to the cephalic cartilage. Annelids move by subcutaneous muscles, stings, and bristles. The Rotatoria revolve by a retractile vibratile apparatus. Crustaceans have usually two legs to each segment, and the Myriapods sometimes four. Some of these appendages are tactile, some for oars, and some ambulatory. Spiders have four pairs of legs, and insects three.

287. Examples of Muscular Strength.—There are some remarkable examples of muscular strength among the lower animals. A flea harnessed will draw from seventy to eighty times its own weight, while a horse can not draw more than six times his weight. The flea weighs less than a grain, and will clear several feet at a leap. The common dorr beetle, weighing but fifteen grains, has been known to heave a weight placed upon him amounting to 4,769 grains, equal to nearly 320 times his own weight.

288. Length of Time the Muscles can be Employed.—The length of time during which some muscles can be employed without rest is also very remarkable. Many birds will fly uninterruptedly for hundreds of miles, and it is also said that insects will remain suspended in the air a whole summer's day without alighting.

289. Rate of Flight of Birds.—Some birds fly sixty feet in a second; but a race-horse scarcely ever exceeds forty feet in the same time. A falcon of King Henry II. flew on one day from Fontainebleau to Malta, a distance of about 1,000 miles. The rice-bird, which afterwards becomes the reed-bird of Delaware Bay and the bobolink of New York, is often found below Philadelphia with green rice in its crop. The same thing is true of pigeons during the rice-growing season.

287. State the power of a flea compared with a horse. 288. What is wonderful about the length of time that some insects can use their muscles without weariness? 289. With what speed can some birds fly? Give the instance of King Henry's falcon.

CHAPTER THIRD.

THE NUTRITIVE SYSTEM.—SPLANCHNOLOGY, OR HISTORY OF THE DIGESTIVE ORGANS.

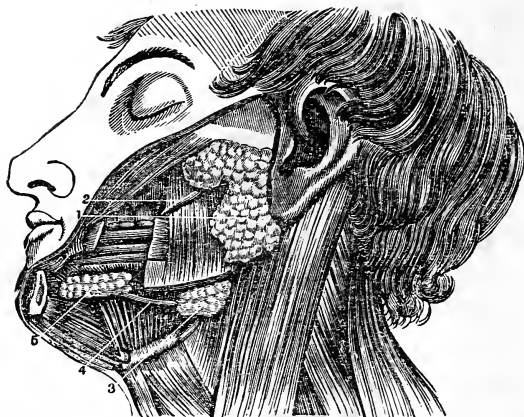
DEFINITIONS AND DESCRIPTIONS.

290. Definition of Digestive Organs.—The Digestive Organs are those which receive the food into the body and effect such changes in it that the various tissues can be formed from it by means of the glands. Of these organs the principal one is the Alimentary Canal. This commences with the mouth, and includes the stomach, with the whole length of tube known as the intestines. This canal, in a full-grown man is about thirty feet in length, being as a general rule five times the height of the individual, and is lined throughout its entire length by mucous membrane.

291. The Mouth; Salivary Glands; the Tonsils.—The Mouth contains the organs of mastication including the teeth and tongue, and receives the saliva, which is secreted by three pairs of glands named Parotid, Submaxillary, and Sublingual, situated just beneath and behind the lower jaw. Besides these three glands there are many other minute glands and follicles situated upon the floor and backsides of the mouth, which secrete fluids that aid in mastication and digestion. The Tonsils are simply an aggregation of follicles situated in

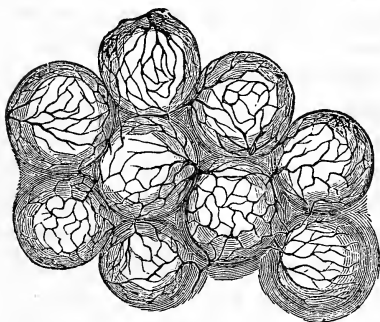
290. What are Digestive Organs? Give the general description of the Alimentary Canal. 291. What does the mouth contain? Name the three principal pairs of glands and give their location.

FIG. 165.



A View of the Salivary Glands in situ. 1, The Parotid Gland in situ and extending from the Zygoma above to the Angle of the Jaw below. 2, The Duct of Steno. 3, The Sub-Maxillary Gland. 4, Its Duct. 5, Sub-Lingual Gland.

FIG. 166.



A few Follicles from Human Tonsil.

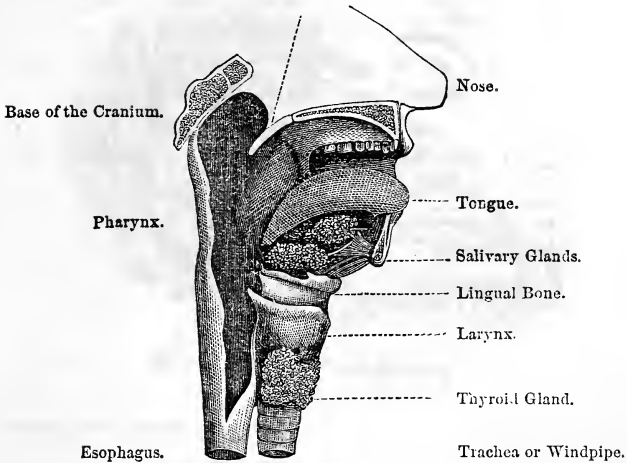
the upper part of the fauces or throat, a few of which are represented in Fig. 166. The mouth is a variable cavity having no empty space within it when closed, and when fully open, containing nearly half a pint.

292. The Pharynx.—The Pharynx (the Greek name for this portion of the body) is the next division of the alimentary canal. It is a short and somewhat irregular tubular cavity, into which the mouth opens behind, serving as a portion of the canal

What are the Tonsils? Are there any other glands in the mouth? 292. Describe the Pharynx.

Fig. 167.

Pendulous Palate.



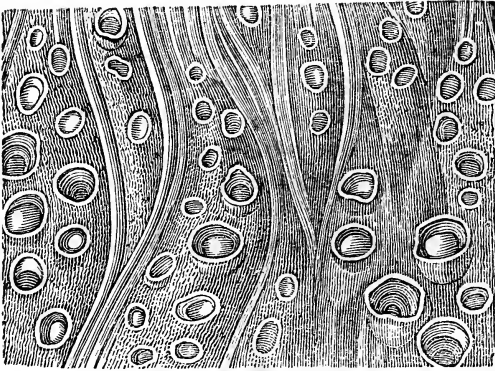
Vertical Section of the Mouth and Throat.

from the mouth to the stomach, its lower limit being nearly opposite to the Pomum Adami (Adam's apple) in front, and the fifth cervical vertebra behind. It also communicates with both ears, with the nostrils and lungs, by passages which open directly into it. The communication between this cavity and the mouth may be entirely cut off by means of a movable muscular curtain called the soft or pendulous palate, which is of great service in the act of swallowing. This portion of the alimentary canal is made up of muscular fibers which run in two directions, so as to cross each other at a large angle, in order to give the most perfect compression upon the food as it passes through it. And in its lining (mucous) membrane are found a great number of follicles or sac-like bodies of microscopic size called Pharyngeal Glands.

293. Esophagus.—The Pharynx terminates in the Esophagus (meaning the passage for conveying the food). This

What cavities does it communicate with? What is said of its muscular coat? 293. What is the Esophagus?

FIG. 168.

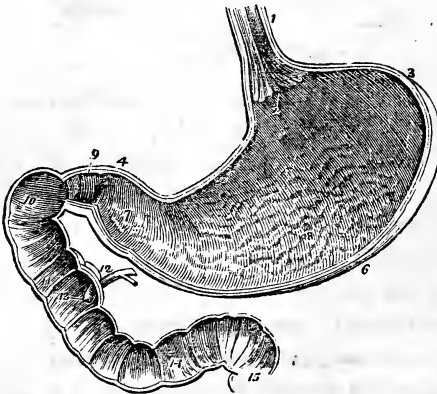


Glands of Esophagus Magnified fifteen Times.

is a long and narrow tube, made up of two muscular coats, which terminates in the stomach by the cardiac orifice. It is smaller in size than the Pharynx, and contains a great number of minute glands, (see Fig. 168), which secrete an oily fluid when the food is passing through it.

294. Stomach, its Coats, its Size, its muscular Coat,

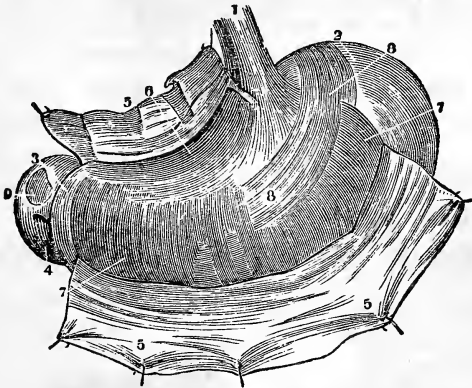
FIG. 169.



Section of Human Stomach. 1, Esophagus. 2, Cardiac Orifice. 3, 4, 5, 6, Greater and Lesser Curves of the Stomach. 7, Dilatation, or rudiment of a Second Stomach. 8, Folds of the Mucous Membrane. 9, Pyloric Orifice. 10, 11, and 14, Duodenum. 12, Duct of Pancreas and Liver. 13, Jejunum.

Gastric Follicles.—The Stomach is the largest expansion of the alimentary canal, situated in the upper portion of the left side of the abdomen, immediately beneath the diaphragm, inclining obliquely downwards from the left to the right. Its walls are made up of three coats: an outer or serous, a middle or muscular, and an inner or mucous. Its normal or average size will allow it to contain about a solid quart, but in gormandizers, and wine and beer drinkers, it is dilated to three or four times that size. In the middle or muscular coat (Fig. 170) the fibers run at right angles to each other, in order that

FIG. 170.



A Front View of the Stomach, distended by flatus, with the Peritoneal Coat turned off. 1, Anterior Face of the Esophagus. 2, The Cul-de-Sac, or greater Extremité. 3, The lesser or Pyloric Extremité. 4, The Duodenum. 5, 5, A portion of the Peritoneal Coat turned back. 6, A portion of the Longitudinal Fibers of the Muscular Coat. 7, The Circular Fibers of the Muscular Coat. 8, The Oblique Muscular Fibers, or Muscle of Gavard. 9, A portion of the Muscular Coat of the Duodenum, where its Peritoneal Coat has been removed.

they may contract in the most efficient manner upon the contents of the stomach for the purpose of digestion, and forcing the contents onwards into the Duodenum. They also assist in forcing the contents of the stomach backward in vomiting. In the inner or mucous lining are situated an immense num-

294. Where is the Stomach situated? What is its normal size? How many coats has it and what are they? Of what service is the muscular coat? What glands are contained in the mucous membrane of the stomach?

ber of tubular glands which open directly into the stomach. They are cup-shaped cavities about the $\frac{1}{35}$ th of an inch in diameter, and $\frac{1}{4}$ th in length, from the bottom of which project two or more parallel tubes, ending in a closed termination in the tissue beneath. These compose the greater por-

FIG. 171.

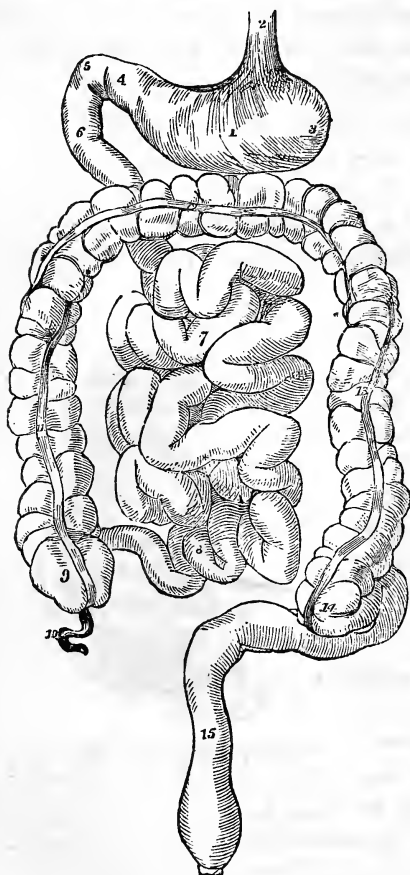
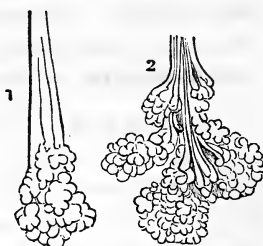


Diagram of the Stomach and Intestines. 1, Stomach. 2, Esophagus. 3 and 4, Stomach. 5 and 6, Duodenum. 7, Jejunum. 8, Ileum. 9, Cæcum. 10, Vermiform Appendix. 11, 12, 13, 14, Colon. 15, Rectum.

FIG. 172.



The Glands in the Coats of the Stomach, magnified forty-five diameters. 1, A Gastric Gland, from the middle of the Stomach. 2, Another, of more complex structure, and appearing to contain Mucus—from the neighborhood of the Pylorus.

tion of the mucous membrane, and are for the purpose of secreting the gastric juice, and probably the Pepsin also. In addition to these glands, a large number of the mouths of veins open into the stomach, which act the part of absorbent vessels to remove the water, whether pure or mixed with other substances.

295. Duodenum.—

The first division of the Intestines is the Duo-

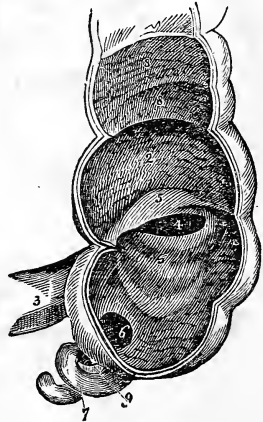
denum, because in length it is equal to the breadth of twelve fingers. It commences with the pyloric orifice on the right extremity of the stomach, and runs slightly backwards and upwards until it terminates in the Jejunum. It is often called the second stomach, because a certain part of digestion takes place here, and the food passes slowly and receives no less than three different secretions: one from the Liver, another from the Pancreas, and the third from the Mucous membrane of the intestine itself.

296. Jejunum.—Next below the Duodenum is the Jejunum, meaning “empty,” since it is always found in this condition after death. This, like the other divisions of the intestine, has three coats, and is of a slightly pinkish color, because here the mucous membrane is thicker than in any other of the intestines.

FIG. 173.

297. Ileum.—The Ileum (from the Greek signifying to twist) is the third division of the Intestines, and is about fifteen feet in length. It is the smallest Intestine, and has a darker color than either of those already mentioned, and is exceedingly tortuous in its course.

298. Cæcum.—The fourth division of the Intestine is the Cæcum. This is a shut sac much larger than the small Intestine, and of a



The Cæcum and its Appendix. 1, Cæcum. 2, Colon. 3, Ileum. 4, Entrance from Ileum to Colon. 5, Ilio-Cæcal Valve. 6, 7, 9, Parts of the Appendix Cæci.

What do they secrete? What vessels open into the stomach, and of what service are they? 295. What is the Duodenum? Give its general course. Why is it sometimes called the second stomach? What fluids are poured into it? 296. What is the name Jejunum derived from? What is its color? 297. How long is the Ileum? What is said of its shape? 298. Name the fourth division of the intestines. Describe it.

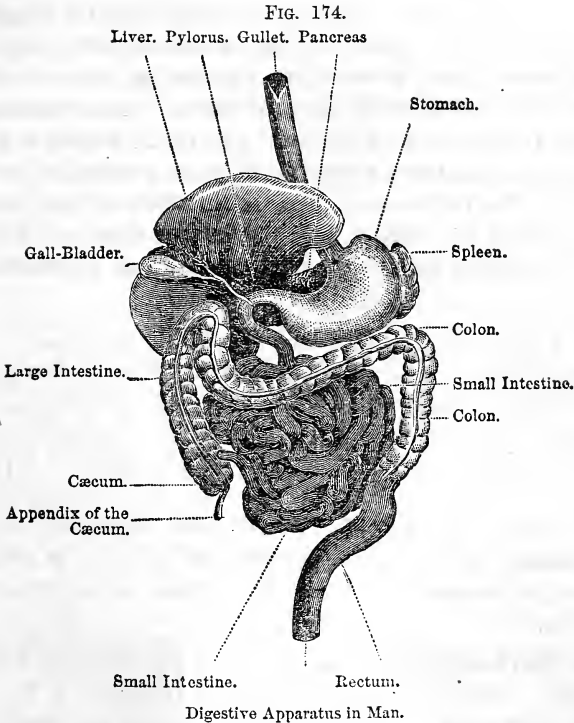
grayish blue color, and not exceeding three inches in length. The entrance of the Ilium into the Cæcum is effected by a valvular arrangement which allows the food to pass into the Cæcum, but never in the opposite direction. It is situated at the right Innominatum in the lower part of the abdomen, and its lowest portion has a worm-shaped process attached to it, which is only rudimentary, and consequently of no great service to man, but largely developed and of great service in some of the lower animals, and especially in the herbivorous ones.

299. Colon.—The Colon (from the Greek signifying “to prohibit,” since the food passes very slowly through this part of the canal), commences at the Cæcum on the right side of the abdomen, and in the first part of its course passes in an upward direction, and is called the ascending Colon. When it reaches the lower edge of the liver, it crosses horizontally to the extreme left edge of the body, constituting the transverse Colon. After this it descends, and joins the Rectum, forming the descending Colon. Its length is from five to eight feet.

300. Rectum.—The Rectum completes the divisions of the Intestines. It is nearly straight in its course, of a larger size than any other division of the canal, except the stomach, and from six to eight inches in length. Its name is derived from the straight direction which it assumes.

301. Division of the Intestines into small and large.—The last three divisions have a much larger diameter than the first three, and are called on that account the large Intestine, and the Duodenum, Jejunum and Ilium, the small Intestine. The latter seems to be the portion necessary for preparing the food to enter the Lacteals, while the large Intestines act mainly as a receptacle for the waste portion.

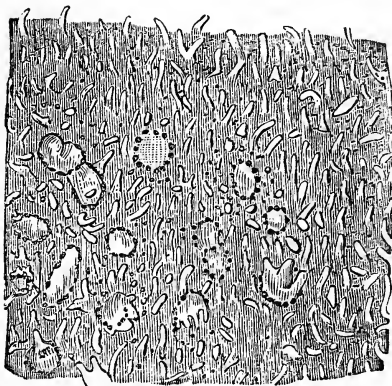
Where is its location in the body? What curious appendage is attached to it? 299. What are the three divisions of the Colon? How long is it? 300. What does the Colon terminate in? How long is the Rectum? 301. Define the large and the small Intestine, and give their probable uses.



302. **Structure of Intestines, Intestinal Glands.**—Like the Stomach, the Intestines are formed by three membranes. Also in the inner or mucous membrane are situated an immense number of microscopic glands, so that a French teacher speaks of them existing “as numerous as the stars in the starry heavens.” They are distinguished as Duodenal Glands, Brunner’s Glands, Solitary Glands, Peyer’s Patches, and Follicles of Lieberkühn. (Fig. 175, p. 164.) They are most abundant along the course of the Ileum and they seem to be especially affected in Typhoid Fever, although no certain use for them in health has as yet been discovered. The

302. What is the structure of the Alimentary Tube? What is said of the Glands found in its mucous lining? State their names.

Fig. 175.

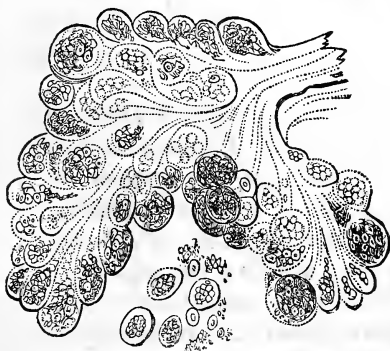


A Portion of the Ilium highly magnified, showing Peyer's Patches and the Villi.

supply from these secretions. Minute Villi or hair-like projections are also found in great abundance upon this mem-

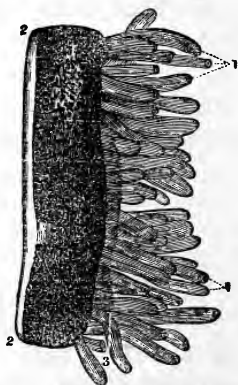
Follicles of Lieberkühn are found only in the large intestine. The Mucous membrane of this part of the canal, is not smooth and continuous with the serous or outer layer, but is doubled upon itself in a great number of folds, in order that the surface containing these glands may be the largest that is possible, so that the contents of the Intestine may receive a large

FIG. 176.



A Portion of one of Brunner's Glands.

FIG. 177.



A View of a Longitudinal Section of the Jejunum, showing the Villi as seen under the Microscope. 1, 1, The Terminal Orifices of the Villi. 2, 2, The Internal Coats of the Intestine. 3, The Peritoneal Coat.

How is the Mucous membrane arranged through the canal, and what is the design of such an arrangement?

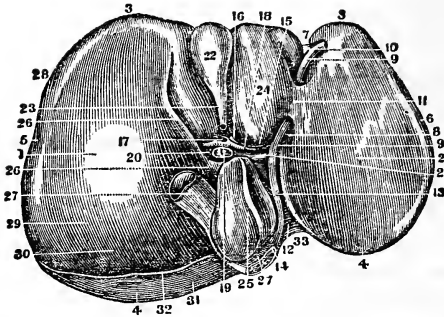
brane, in order to increase the amount of its secretory surface. It is the presence of villi that gives to some parts of the mucous membrane a velvet-like appearance, and in these villi are found the commencement of the lacteals, one lacteal usually being found in each villus.

303. Glands attached to the Intestines.—Connected with the Alimentary Canal are several large glands, a few of which have already been described. They are soft solids, of various forms and sizes, and are composed of lobules or small divisions, each one of which is supplied with an artery, vein, and duct. Each of these ducts communicates with the principal duct or outlet, which conveys away the product separated from the blood by the whole gland. In microscopic structure, a gland is made up of very minute cells, which seem to have the power of secreting or separating from the blood the particular substance which it is the function of the gland to eliminate.

304. The Liver, Gall-Bladder.—First in importance of this class is the Liver. (Fig. 178, p. 166.) This, excepting the brain, is the largest organ in the body, and is situated on the right side of the abdomen, corresponding to the stomach on the left, and is of a reddish yellow color. The average weight of it is four pounds, measuring twelve inches in its longest diameter, and it is divided into five lobes or great divisions, and these are entirely composed of minute bodies or lobules, (Fig. 179, p. 166), which are about the size of millet seeds, each one containing an artery, a vein, and a plexus, or net-work of ducts for conveying away the bile. These different plexuses unite with each other and form two hepatic ducts which discharge the bile into the Gall Cyst or bladder. (Fig. 180, p. 167.) This is a pear-shaped sac, containing from one to two ounces, of a greenish yellow color, situated under

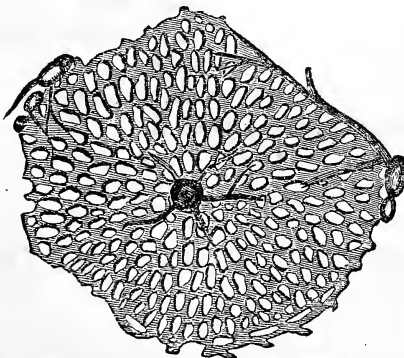
Describe the Villi. 303. What is said of the large glands connected with the organs of digestion? State the structure of a gland. 304. What is the relative size of the Liver? Where is it located? State its color and weight. Give its minute structure. What is the Gall Cyst or Bladder? What is the duct that carries the Bile to the Gall Cyst, and the one that empties the Gall Cyst into the Duodenum?

FIG. 178.



The Inferior or Concave Surface of the Liver, showing its Subdivisions into Lobes. 1, Center of the Right Lobe. 2, Center of the Left Lobe. 3, Its Anterior, Inferior, or Thin Margin. 4, Its Posterior, Thick or Diaphragmatic Portion. 5, The Right Extremity. 6, The Left Extremity. 7, The Notch on the Anterior Margin. 8, The Umbilical or Longitudinal Fissure. 9, The Round Ligament or remains of the Umbilical Vein. 10, The Portion of the Suspensory Ligament in connection with the Round Ligament. 11, Pons Hepatis, or Band of Liver across the Umbilical Fissure. 12, Posterior End of Longitudinal Fissure. 13, 14, Attachment of the Obliterated Ductus Venosus to the Ascending Vena Cava. 15, Transverse Fissure. 16, Section of the Hepatic Duct. 17, Hepatic Artery. 18, Its Branches. 19, Vena Portarum. 20, Its Sinus, or Division into Right and Left Branches. 21, Fibrous remains of the Ductus Venosus. 22, Gall-Bladder. 23, Its Neck. 24, Lobulus Quartus. 25, Lobulus Spigelii. 26, Lobulus Caudatus. 27, Inferior Vena Cava. 28, Curvature of Liver to fit the Ascending Colon. 29, Depression to fit the Right Kidney. 30, Upper portion of its Right Concave Surface over the Renal Capsule. 31, Portion of Liver uncovered by the Peritoneum. 32, Inferior Edge of the Coronary Ligament in the Liver. 33, Depression made by the Vertebral Column.

FIG. 179.

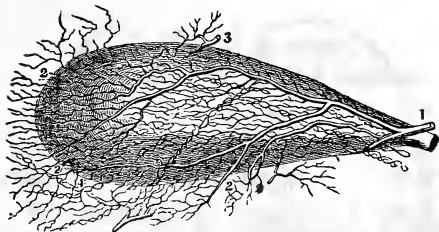


Transverse Section of a Lobule of the Human Liver.

the right side of the liver, and has a small vessel called the Bile Duct, which enters the Duodenum obliquely about three inches from the stomach.

305. Pancreas.—The Pancreas ("all flesh," because there is no fat ever found in it) is another

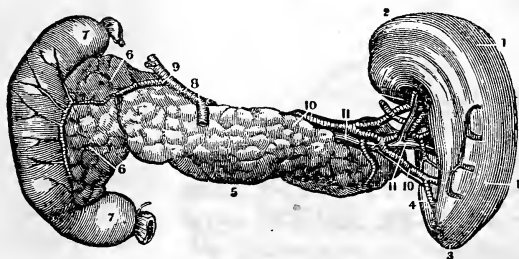
FIG. 180.



A View of the Gall-Bladder distended with Air, and with its Vessels Injected. 1, Cystic Artery. 2, The Branches of it which supply the Peritoneal Coat of the Liver. 3, The Branch of the Hepatic Artery which goes to the Gall-Bladder. 4, The Lymphatics of the Gall-Bladder.

gland, lying directly behind the stomach. It is about six inches in length, the right end of it being somewhat larger than the left extremity, and hence called the head. To the naked eye the lobular structure is apparent: but each lobule is itself made up of much smaller lobules. The duct of the Pancreas conveys the milk-like secretion of this gland, to nearly the same point on the Duodenum as the Hepatic Duct, where they both enter that tube in a slanting manner, so that by the valvular arrangement the contents of the intestine can not be forced backwards into the Biliary or Pancreatic duct.

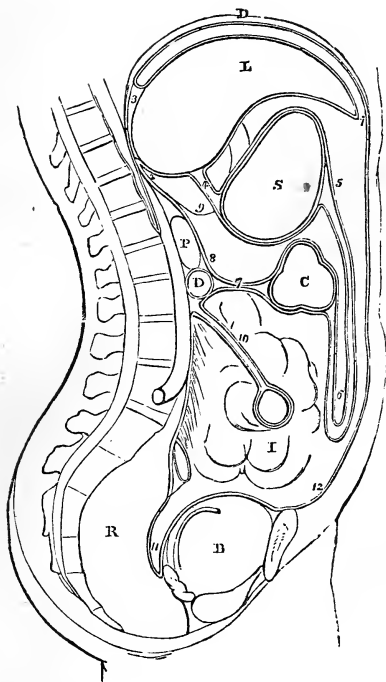
FIG. 181.



An Anterior View of the Pancreas, Spleen and Duodenum, with their Blood-Vessels Injected. 1, The Spleen. 2, Its Diaphragmatic Extremity. 3, Its Inferior Portion. 4, The Fissure for its Vessels. 5, The Pancreas. 6, Its Head, or the Lesser Pancreas. 7, Duodenum. 8, Coronary Arteries of the Stomach. 9, The Hepatic Artery. 10, The Splenic Artery. 11, The Splenic Vein.

305. Describe the Pancreas. What is its structure? Where does its duct empty, and what mechanical structure in it makes it remarkable?

FIG. 182.



Reflexions of the Peritoneum. *D.* Diaphragm. *S.* Stomach. *C.* Colon. *D.* Duodenum. *P.* Pancreas. *I.* Small Intestine. *R.* Rectum. *B.* Bladder. The numbers indicate the course of the Peritoneum.

306. Peritoneum.—

The Peritoneum, “covering about,” or external coat of the intestines is not a little peculiar in its conformation. This, like all serous membranes, first completely invests the organs and then is reflected from them so as to make a lining for the whole cavity. Hence the cavity of the abdomen, although a perfectly shut sac, is of very irregular outline. That it is a shut sac may be seen from the fact that in dropsy of the abdomen—the fluid has no means of escape except by absorption, or puncture from the outside. In the disease commonly known as inflammation of the bow-

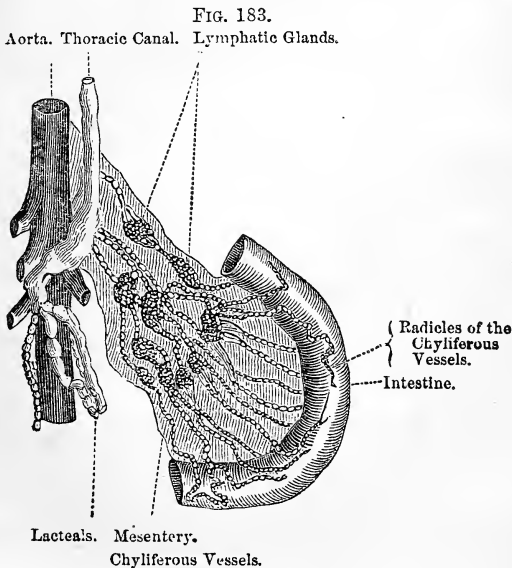
els, this membrane is the principal seat of the difficulty, and the inflammation of this as well as of all other serous membranes, is attended with acute pain, and the progress of the disease, for better or worse, very rapid.

307. The Mesentery and the Omentum.—These are folds of the Peritoneum, attached to different parts of the abdomen and its viscera, which serve to retain some of the organs in

303. What is the Peritoneum? Is the cavity of the abdomen of a regular outline? What is the principal seat of disease in inflammation of the bowels? 307. What is the Mesentery and the Omentum? What is it thickly packed with?

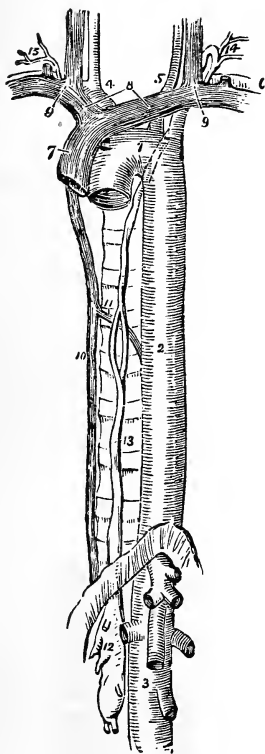
their position, and also, from the amount of fat contained in them, to protect the intestines from cold and mechanical violence, and to furnish a soft surface for them to glide over in their various movements. In a lateral view of the abdomen, Fig. 182, some of the parts of the Omentum and Mesentery may be seen. At 4 is seen what is known as the lesser Omentum, connecting the Liver and the Stomach. At 5 and 6 are seen the folds which constitute the greater Omentum. At 10 is found the Mesentery, which encircles the small intestines. This is a broad fold of the Peritoneum connected to the middle of the cylinder of the Jejunum and Ileum through their whole length, and is attached to the posterior wall of the abdomen. Within the layers of the Mesentery are found from 130 to 150 bodies of almond shape and size, known as the Mesenteric Glands. Through these the Lacteals pass on their way to form the Thoracic Duct.

308. Lacteals.—The Lacteals are minute vessels, which commence with the inner or mucous coat of the intestines,



What small bodies are found in it, and what is the use of the Mesentery ?

FIG. 184.



A View of the Course and Termination of the Thoracic Duct. 1, Arch of the Aorta. 2, Thoracic Aorta. 3, Abdominal Aorta. 4, Arteria Innominata. 5, Left Carotid. 6, Left Sub-Clavian. 7, Superior Cava. 8, The two Venæ Innominatæ. 9, The Internal Jugular and Sub-Clavian Vein at each side. 10, The Vena Azygos. 11, The Termination of the Vena Hemi-Azygos in the Vena Azygos. 12, The Receptaculum Chyli: several Lymphatic Trunks are seen opening into it. 13, The Thoracic Duct dividing, opposite the Middle Dorsal Vertebra, into two branches, which soon re-unite; the course of the Duct behind the Arch of the Aorta and Left Sub-Clavian Aorta is shown by a Dotted Line. 14, The Duct making its turn at the Root of the Neck and receiving several Lymphatic Trunks previous to terminating in the Posterior Angle of the Junction of the Internal Jugular and Sub-Clavian Veins. 15, The Termination of the Trunk of the Lymphatics of the Upper Extremity.

803. Where do the Lacteals begin, and where do they terminate? What do they resemble, and what do they pass through? State the size of the Thoracic Duct, its course and termination.

and terminate in the Thoracic Duct. These at their commencement are about the same in anatomy with the radicles or small veins, and at this point act the part of absorbents. Soon after they have left the Intestines, several of them unite into one and pass through small bodies of about the size of peas, called the Mesenteric Glands. As they emerge from these glands, they are fewer in number but larger in size, until they all unite into one tube called the Thoracic Duct, a little larger than a goose quill, at about the point of the last Dorsal Vertebra. This vessel passes immediately upwards, lying closely upon the Spinal Column, sometimes separating into two smaller tubes for a few inches,

until it reaches a point as high as the clavicle, where it gradually curves forward, and joins itself to the left sub-clavian vein. The Lacteals and Thoracic Duct are all made up of three coats and present a silvery white appearance from the color of the fluid they contain. Their function is to convey the Chyle or nutrient portion of the food into the blood.

309. Kidneys.—The Kidneys are two in number, situated upon the side of the lumbar vertebræ, and are generally enclosed in a large amount of fat. Their average size is between four and five inches in length, two and a half inches in breadth, and one in thickness. Their color is of a reddish yellow, and form decidedly oval, with a depression in one of the sides. Upon its upper extremity is a small body, called the Renal Capsule, and the whole organ is abundantly supplied with blood. The design of it seems to be the removal

FIG. 185.

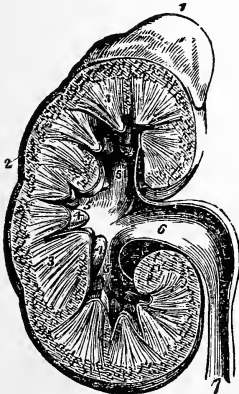


FIG. 186.

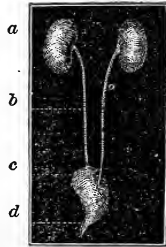


Diagram of the Urinary Apparatus. *a*, The Kidneys. *b*, The Ureter. *c*, The Bladder. *d*, Canal of the Urethra.

A Section of the Right Kidney surmounted by the Renal Capsule. 1, Supra-Renal Capsule. 2, Cortical Portion. 3, Medullary or Tubular. 4, Two of the Calices receiving the Apex of their corresponding Cones. 5, The Infundibula. 6, The Pelvis. 7, The Ureter.

What vein does it empty into? What fluid does it carry? 309. State the leading features of the Kidneys. What is found upon its upper edge?

of the waste Nitrogen of the system, and many salts, especially the Phosphates, which can be eliminated by no other organ. The secretion of the kidneys is the urine, upon the regular secretion of which the health of the system greatly depends.

FUNCTIONS OF THE DIGESTIVE ORGANS.

310. Mastication; Use of the Tongue; Use of the Saliva. Amount of Saliva.—The first process through which the food must pass is Mastication, or reducing it to a pulp by means of the teeth and admixture of the saliva. The service of the tongue is to keep the food between the teeth and to place it in such a position that it will readily receive the saliva. The saliva is of use to moisten the food, since the gastric fluid will much more readily dissolve it than if dry or solid. It aids articulation and the sense of taste by keeping the lining of the mouth in a moist and pliant state. It also is of use to cleanse the mucous membrane, and by its moisture to quench or prevent thirst. Air is also carried by it into the stomach to aid the process of digestion. But the most important use of this fluid is the conversion of starch into sugar. This property depends mainly upon a peculiar organic active substance contained in it called Ptyalin, and is most active when in a state of incipient decomposition. The saliva secreted daily varies, according to different authorities, from about three pounds to six pounds and a half, and is alkaline in its character. Acid, aromatic, and pungent substances increase the amount of the secretion very much.

311. Deglutition. A part of the Process involuntary. —After mastication, the next process is that of swallowing, or deglutition. The first step is to place the bolus, or mouthful, upon the back part of the tongue, when by

Of what great use are the Kidneys? 310. Describe the process of Mastication. Of what use is the Saliva? How much is secreted every day? What increases its amount? 311. Describe the process of swallowing.

the muscles of the tongue and fauces it is forced into the Pharynx. As soon as it fairly enters this passage, the muscles by an involuntary movement seize it, and force it rapidly past the opening into the lungs, and at the same moment the epiglottis is forced down upon the larynx, to prevent its entrance into the trachea. This part of the process is involuntary, from the necessity of keeping the passage to the lungs open as much as possible, in order to admit air, and also from the great danger of introducing any other substance. And so perfectly carried on is this function that it is seldom—compared with the frequency of deglutition—that even a fluid escapes the vigilance of this sentinel.

312. Passage of the Food through the Esophagus.—The food passes slowly through the Esophagus into the stomach, it being forced along by the contraction of the muscular fibers, aided by the oily secretion of the Esophageal glands.

313. Gastric Digestion.—As soon as the food reaches the stomach, the most important part of the process of digestion commences, all the previous steps being preliminary. Whenever any solid substance comes in contact with the inner or mucous membrane of the stomach, it excites the gastric glands to pour out in abundant quantity the Gastric fluid.

314. Gastric Fluid—its Amount—Pepsin.—This fluid is a transparent liquid of a little greater consistency than water, and of a perceptibly acid taste. It possesses the property of coagulating albumen, and of separating the whey or serum from the milk in a very short time, and is secreted at the rate of seventy ounces per day. This property, however, is owing to a peculiar organic compound called Pepsin, which acts after the manner of a ferment at the normal temperature of the human body. The Gastric fluid also possesses antiseptic

What part of the process is under, and what part is not under the control of the will? 312. How is the food carried through the Esophagus? 313. Where does the most important part of digestion take place? What effect has any solid substance upon the Gastric Glands of the Stomach? 314. What are the properties of the Gastric Fluid? How much is secreted daily? What effect has it on the decay of substances?

properties, or the power of preventing decay or putrefaction for a long time. These three properties, the acid, fermentative, and antiseptic, are of service in the following manner. The acid assists in the solution of the different materials in the stomach. The Pepsin, which constitutes two thirds of the solid materials of the gastric juice, does its office by establishing the lactic fermentation, such as is seen in the changes through which milk passes in hot weather. The antiseptic properties are important in order to prevent putrefaction, which would be so liable to be set up among organic substances in such a condition, and at such an elevated temperature as the stomach usually possesses.

315. Digestion partly dependent on Chemical Action.— Thus we see that this part of digestion is mainly a chemical affair, although not entirely so: since by experiments carefully conducted in a vial outside of the body, maintaining the same temperature and all the essential conditions of digestion, the process goes on very slowly and quite imperfectly. It was found, however, that a piece of meat did digest in a vial in nine hours and a half, while that in the stomach under precisely similar circumstances, was digested in one hour and a half.

316. Digestion partly a vital Process.—Consequently to say exactly what stomach digestion is, must at present be impossible. We can only say that it is a chemico-vital process, essentially a chemical action depending upon vital power.

317. Movements of the Stomach in Digestion.— In order to bring the food in contact with the largest amount of Gastric Fluid, the stomach, by an instinctive movement, carries its contents over the greater curve in it, from the right to the left, and returns it in a reverse direction, occupying about

What constituent is it that is primarily essential in this process? 315. How much of the process thus far described is mainly a chemical one? What experiment proves it? 316. What definition can be given of Digestion? 317. What instinctive movements does the stomach seem to possess?

three minutes for each revolution. And in order that all of it may be permeated by this fluid, contractions frequently take place in the muscular coat of the stomach, resembling a churning process.

318. *Intestinal Digestion, Chyme.*—The process thus far is *Gastric Digestion*, or that which takes place in the stomach, and the object accomplished seems to be the conversion of the nitrogenous constituents of the food into albuminose called *histogenetic digestion*, or the preparation of the food to be made into the tissues of the body. But when all the food is thoroughly dissolved, or made into a liquid condition called *Chyme*, the *Pyloric orifice* is opened, and the food passes into the *Duodenum*. When it arrives here—and never sooner, in a healthy state—the secretions of the *Liver*, *Pancreas*, and *mucus of the Intestine* mix with it, performing the second or *Intestinal digestion*, which is called *calorific* or *heat making*, since it prepares the food which supports the heat of the body. The process, however, is somewhat obscure, although it is certain that food is not perfectly fitted for absorption until it has well completed this process.

319. *Use of the Pancreatic Fluid.*—The *Pancreatic Fluid* secreted at the rate of from five to seven ounces per day, resembles quite closely the *Saliva*, converting starch into sugar, and aiding in the absorption of fatty matters, by forming an emulsion, which, however, is much more readily formed by the presence of bile.

320. *Action of the Bile, an Antacid and Excretory Agent.*—The *Bile*, thrown out at the rate of fifty-four ounces a day, seems from its large quantity to be of no little importance. And since the juices of the stomach are mostly acid in their character, it seems desirable that there should be some counteracting agent, which is furnished in the

318. What is the principal thing accomplished by stomach digestion? What is food called after it has passed through this process? Describe Intestinal digestion and its use. 319. What amount of Pancreatic fluid is secreted daily? What is its principal use? 320. How much Bile is secreted daily?

highly alkaline character of the biliary secretion. Another use of the bile is to remove certain materials from the blood (the carbonaceous), by allowing them to pass off with the waste portions of the food, the liver thus performing the office of an excretory organ. The liver also seems to possess the power of forming sugar and even fat, when it is not contained in the food, thus seeming to act the part of an equilibrator in the process of blood making. And since all the blood returning from the small intestines passes through the liver before going to the heart, without doubt an important change is accomplished in it by the liver, although the change is as yet by no means fully understood.

321. Purposes for which Food is required. Two kinds of Materials in the Food, azotised and non-azotised. Azotised Constituents. Albumen, Fibrine, Casein, Gelatin.—In the animal body we find that food is required for at least three purposes: First, to build up the organism at the outset, or, in other words, to secure its first growth. Second, to maintain the organism at its normal standard after its growth is complete, or to furnish material to supply the waste which is perpetually going on while life lasts. Third, to maintain the proper temperature of the system. Hence there must be at least two kinds of material contained in the food: one that will sustain and promote the growth of the tissues called histogenetic, and another that will keep up the heat of the body to a proper standard, called calorific. The first of these requisites is found in food containing Nitrogen, called azotised, and the other in that with no Nitrogen, called non-azotised. Of the azotised food the most important constituents are Albumen, Fibrine, Casein, and Gelatin. Albumen is familiarly known as the transparent portion of an egg before it is cooked, or the white of the egg after a cooking process. It exists also in the blood, muscles, and bones of all animals, and is

How is its alkaline character serviceable? What other processes does it accomplish?
 321. What three purposes is food required for? Hence what two kinds of food must be brought into the system? Give examples of azotised food.

coagulated or made hard and white by heat or mixture with Nitric Acid. In some parts of vegetables also, especially in the seeds and fruit, is found a substance which, from its resemblance to animal albumen, is called vegetable albumen. Fibrine exists in the blood and muscles of animals, forming the coagulum or clot of blood, and the proper muscular substance. There is also a corresponding substance in plants known as vegetable Fibrine. Casein closely resembles Albumen in its constitution, but differs in many of its physical properties. For while Albumen is coagulated by heat, Casein is only coagulated by lactic and acetic acids. Casein is best seen in cheese. These three substances are the essential elements of nutrition in mammals, and though every other principle may be supplied in the food, yet the body is insufficiently nourished without Albumen and Fibrine. Gelatin, which exists abundantly in the cartilage of animals, is another azotised principle of food. This, however, of itself can not support life, although it can be changed into albumen, or some of its compounds by the action of the fluids of the stomach.

322. Non-azotised Constituents.—Of the non-azotised constituents of food, the Saccharine and Farinaceous and Oily, are the principal ones, although there are many others of less importance. Of the former, the principal element is starch, while the sugar is secondary or subsidiary to it, and in the latter we find an abundance of a Hydro-Carbon, or a compound of Hydrogen, Carbon, and Oxygen, and all are essential elements in combustion.

323. Is an exclusively Animal or Vegetable Diet the best adapted to Man? Testimony of Experience. Experience of Dr. Kane.—The question then which naturally suggests itself here is, whether man is adapted to live ex-

What effect has heat and Nitric Acid upon Albumen? Where is Fibrine found? How does Casein differ from Albumen? Will Gelatin (or Jelly) of itself support life? 322. What are examples of non-azotised kinds of food? 323. Is man made to live on an exclusively vegetable or animal diet?

clusively upon vegetable or animal diet. An answer comes to us from both experience and chemistry. For while on the one hand hundreds of examples are adduced, as showing that some men have lived to a green old age in solid health, who have entirely refrained from animal diet, and many others who probably would have shortened their lives a score of years by the use of animal food, have prolonged it by adopting a vegetable regimen, an equal number of cases can be mentioned to show that a mixed diet has promoted equally long and healthy lives. The geographical distribution of man, as well as the manner of life, also furnishes valuable evidence in this case. Travelers who have visited the polar regions, and pre-eminently Dr. Kane, give us undoubted testimony of the necessity of eating meat and animal fat to keep the body in health: since the low temperature not only requires a greater amount of combustive material, but this greater energy of respiration produces a more rapid waste of all the tissues of the body, requiring a more abundant supply of azotised and non-azotised material to supply the deficiency. And on the other hand experience shows that in tropical climates stimulating food and drink should be avoided, because the high temperature of the atmosphere depresses vital energy, and consequently less material for supporting animal heat is required with a corresponding decrease in the waste of the body.

324. Example of the Esquimaux.—As examples of these principles one traveler among the Esquimaux relates that these people relish very heartily tallow candles as a dessert for dinner. Another states that he has seen the Greenlanders eat from twenty to thirty pounds of blubber, or whale-fat, at one meal. This, however, was a sufficiency of food to them for two or three days.

Give the testimony of experience. Give the argument derived from difference in climate. What kind of food is necessary to support life in polar, and what in tropical countries? 324. State luxurious articles of diet among Esquimaux and Greenlanders. How much will a Greenlander sometimes eat?

325. *Voice of Chemistry.*—Chemistry, however, teaches us that we can find in the vegetable world all the principles necessary to support the body without using animal food. And although the vegetable kingdom contains those elements which will support life in many instances, yet we know, *as a general rule*, that we find man in the highest degree of bodily and mental vigor, only when he makes use of a mixed diet. And we also find that all animals which are the most active in their habits, and rapid in their motions, are feeders upon animal flesh. There is also a race of half civilized savages, the Guanchos, who spend the greater part of their lives in the saddle and constantly in a state of great activity, who live almost exclusively upon animal diet, and yet are unequaled in their powers of physical endurance, and live lives fully equal to the average in duration.

326. *Argument from the Teeth.*—The strongest physiological argument in favor of a mixed diet, is found in the conformation of the teeth and alimentary canal of man. In those animals which live exclusively upon animal diet, the teeth are sharp and pointed, with a very short alimentary tube, since the nutrient portion of the food is readily absorbed by the lacteals. On the other hand, the teeth of vegetable feeding animals are smoothed upon their upper surfaces, being adapted to crush vegetable substances, and the alimentary tube very long, since the nutrient portion of vegetable food is not so readily parted with. Now in man we find neither of these apparatuses perfectly complete, but an admixture of both. Part of the human teeth are of the carnivorous or flesh eating kind, and another part of the herbivorous or vegetable eating kind: but each of them so modified, that either kind of food can be readily prepared for digestion. The alimentary canal too is intermediate between that of the carnivorous and herbivorous type, being equally well adapted

325. What does chemistry teach on this subject? How does great bodily activity affect the diet as illustrated by the Guanchos? 326. State the argument derived from the teeth. What two kinds of teeth are found in man?

to the digestion of animal or vegetable food, or an admixture of both.

327. *Conclusions.*—The kind of food which is the most perfectly adapted to the constitution of man, seems to be determined by the following rules, based upon the temperature of the climate, the habits or employments of life, and the health of the individual.

First. The lower the temperature the greater the amount of animal heat necessary for the support of life, which requires the fattest portions of the meat.

Second. The more active the habits of the individual, and the greater the amount of exposure in the open air, the greater the demand for animal food.

Third. If the system be suffering under inflammation of any sort, or if there be any tendency to inflammation, animal food should be used very sparingly, or entirely dispensed with.

Fourth. That diet seems to be the most perfectly adapted to the human constitution in all climates and seasons, which is composed of animal and vegetable food in the proportion of one to two, or one third by weight of animal food to two thirds of vegetable food. This proportion is the basis of the diet scales of the United States and British Navies.

328. *Use of the Lacteals.*—The use of the Lacteals is to absorb the Chyle or nutrient material from the contents of the intestines, and carry it into the general circulation. The force by which this fluid is taken from the alimentary canal, is by no means understood at present, unless it be capillary attraction.

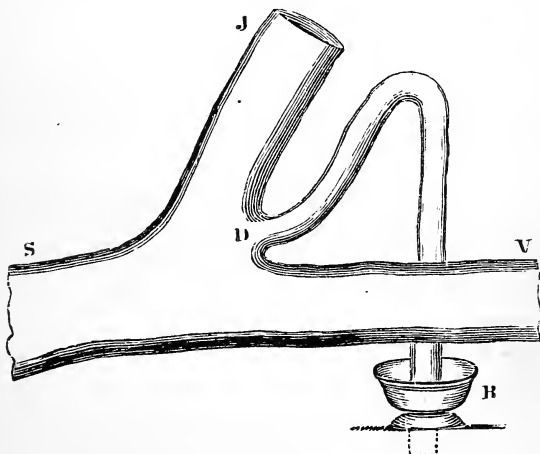
329. *The Chyle.*—The Chyle is a white liquid somewhat thicker than milk, and is made up of a solution of albumen containing minute globules, or cells, which are mostly spher-

327. What four conclusions are drawn from this whole subject of diet? 328. What is the function of the Lacteals? What is the force that circulates the Chyle? 329. Describe the Chyle.

ical and about $\frac{1}{30000}$ th of an inch thick, and Chyle Corpuscles, which are simple cells about $\frac{1}{60000}$ th of an inch in diameter.

330. The Place where the Chyle enters the Blood.—Principle of Venturi.—As already mentioned the Chyle enters the blood through the left Subclavian vein of the neck. It is not, however, simply by the opening of one vessel into another that this is accomplished, but advantage is taken of the union of two currents, so that by their combined force the chyle is drawn in towards the heart. The mouth of the

FIG. 187.



Position of the Thoracic Duct and the Veins of the Neck where it empties.
S. V. Subclavian Vein. J. Jugular Vein. D. Thoracic Duct.

Thoracic Duct, however, is provided with valves to prevent the blood from entering it, in case obstruction in the veins should occur. And "it is a physical fact that, when a small tube is inserted perpendicularly into the lower side of a horizontal conical pipe, in which water is flowing from the nar-

Give the size of the Chyle Corpuscles. 330. Give the description of the hydraulic principle by which the chyle is drawn towards the heart.

FIG. 188.

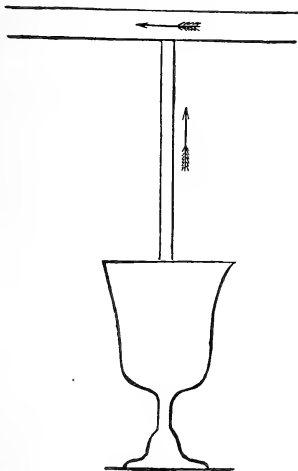


Illustration of the Principle of Venturi. When a current passes through a large tube, if another smaller tube open into its side, the current in this tube will be drawn into the large tube, even against the force of gravity.

rower to the wider portion, if the vertical tube be made to dip into a vessel of water, not only will the water of the larger pipe not descend into the vessel, but it will draw up the water through the small tube so as to empty the vessel." This is called "the principle of Venturi," and is well illustrated by the entrance of the Thoracic Duct into the Subclavian vein, as seen in the cut No. 187. A diagram illustrating the same principle is seen in Fig. 188, the arrows representing the direction of the currents, and the smaller, perpendicular tube illustrating the Thoracic duct at its entrance between the veins of the neck.

331. The Lymphatics.—The Lymphatics in general structure and function resemble the lacteals. The lacteals, however, are designed exclusively for promoting the growth of the body by adding nutrient materials, while the lymphatics give up to the general circulation not only useful products, but all those which are absorbed. Hence whatever is presented to the mouths of the lymphatics, is carried into the general system, while injurious products are not usually taken up by the lacteals. (See also page 284.)

332. The Action effected by the Lymphatics.—Since the Lymphatics, as already described, are found in every

Illustrate the principle of Venturi. 331. Give the general structure of the Lymphatics. State the probable differences in function between these and the Lacteals.

part of the body in great numbers, and are almost constantly at work in removing the waste particles, it follows that in process of time a large part, or even the whole of the body, will be removed. And it is generally admitted that the whole body is actually renewed every few years, although the precise number can not be stated, since so many circumstances modify the change, such as exercise, the amount of food taken, and climate, as well as other causes not so easily understood. It is, however, quite probable that the period of ten years is sufficient to complete the change in most individuals, and the number is stated by some as low as seven.

HYGIENIC INFERENCES.

333. 1. From the structure and functions of the Digestive Organs we can derive some hints as to the manner of preventing acute and chronic diseases in them.

334. Danger of Eating too much.—2. We see that there is *a great danger of eating too much*. Large quantities of food distend the coats of the stomach, and give too much labor for them to perform. As a natural consequence the gastric glands are weakened from excessive action, and then indigestion or some other diseased action is sure to follow. And in how much better health would multitudes in the higher classes of society be kept, if some of the numerous dishes they use were omitted! And in this country the remark applies to nearly all classes.

335. We are apt to eat too many Kinds of Food.—3. We also see that *our meals are generally made up of too many kinds of food*. In the habits of the lower animals we discover a great simplicity of diet. Even in those whose anatomical structure closely resembles that of man, the appetites

332. How great changes are effected in the body by the Lymphatics? In what length of time is the body probably entirely renewed? 334. What is the injury from eating too much? 335. What is said about eating too many kinds of food?

are easily satisfied by the simplest food. Nor does man's intellectual superiority demand a greater variety in diet, all that is requisite being the materials necessary to support the growth of the different tissues.

335a. 4. It is evident that *condiments and spices should be always used very sparingly*, and generally spices not at all. To be sure nature seems to indicate the want of a moderate supply of salt (perhaps for the juices of the stomach), but pepper, mustard, and ketchup excite the coats of the stomach to an action that is unnatural. And it seems to be a law of the system that stimulants and opiates, if used regularly, must be constantly increased in quantity, otherwise they will lose their effect, and disorder will follow. In fine, all experience seems to prove that the demands of nature for food are very simple and easily gratified; but the appetite may be so trained as to loathe every thing of a simple and natural kind, and be satisfied only with the stimulating compounds of modern cookery. The law of nature, however, cannot be reversed, that he who lives in the simplest manner lives the longest, and suffers the least from pain or disease.

336. We must not eat too fast.—5. Most persons *eat too fast*. No time is gained on the sum total of life, by taking any from that demanded by nature for eating and digesting food. A fortune or great reputation, it is true, may sometimes be gained a little quicker by using the time which the stomach rightfully claims, yet the penalty for such robbery is a shorter life, or a disease which makes life miserable.

337. The Time of Eating.—6. We see that *the time of eating should not encroach upon the hours devoted to sleep, or those of hard labor*. During sleep the brain needs quiet; but if there be any function going on such as that in the earlier stages of digestion, the brain, as a matter of necessity,

Does intellectual superiority require so great a variety as is often introduced? 335. Why are condiments and spices to be used very sparingly? What are the demands of nature upon the appetite? How much may the appetite be perverted? 336. What danger in eating too fast? 337. What time during the day should we eat?

must labor till the process is accomplished, and as a result, dreams or imperfect trains of thought will produce that kind of sleep which cannot refresh the body. If again the time for meals precede or follow very closely upon hard labor, a law of nature is broken, and the penalty is sure to follow. The nervous energy cannot be immediately called off from the part to which it has for some time been directed (whether to the brain or the muscles), and consequently the stomach for a while must lie nearly inactive. Hence a short season of relaxation from all active exercise, whether mental or physical, just before and after meals, is very conducive to health, since in the former case the circulation is equalized, and the brain can prepare its energies to expend them on the stomach, while after meals the whole force of the nervous influence is needed for a time by the digestive function before it can be directed to the muscles for exercise. Even a short time after dinner devoted to a nap promotes digestion quite rapidly, although the habit often is an inconvenient one, to say the least, since if by unavoidable circumstances it is omitted for once, the person feels uncomfortable the rest of the day.

338. Danger of employing Stimulants for weak Stomachs.—7. We see the error and danger of a very common practice: that *when the digestive organs become weak, and the appetite is poor, stimulants are employed to waken the stomach to crave more food than it can digest.* This only aggravates the difficulty and makes a demand for stronger stimulants, and thus often is the system prematurely worn out. Whereas, would men follow nature and when a diminished appetite teaches them to eat less and give the organs an opportunity to rest, they would ere long rally and digest all that is necessary to give tone and energy to the system. To

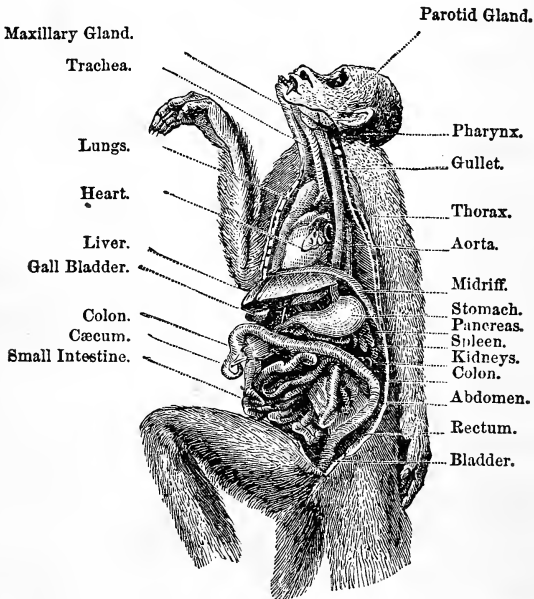
Why should not hard labor and a full meal come closely together? How does a short nap after dinner affect digestion? What is a serious objection to the habit? 338. What danger results from using stimulants to help weak stomachs? Should we eat more than the natural appetite craves?

eat more than the stomach craves, is not the way to gain strength, but to increase weakness and shorten life.

COMPARATIVE SPLANCHNOLOGY.

339. Digestive Organs of Mammals.—In many mammals the digestive organs in their general arrangement and construction resemble those of man.

FIG. 189.



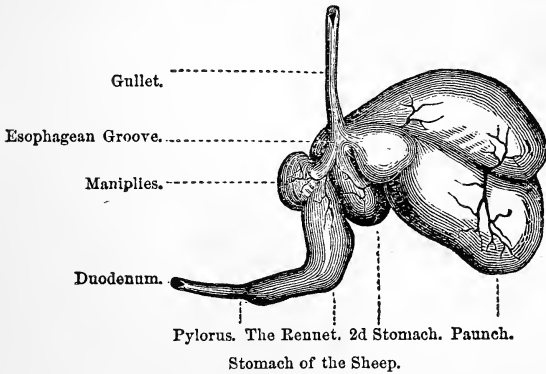
Digestive Apparatus of an Ape.

340. Esophagus of the Horse.—In the Horse, however, at the lower end of the Esophagus, there is a sickle-shaped

fold of lining membrane, which makes it impossible for this animal to vomit.

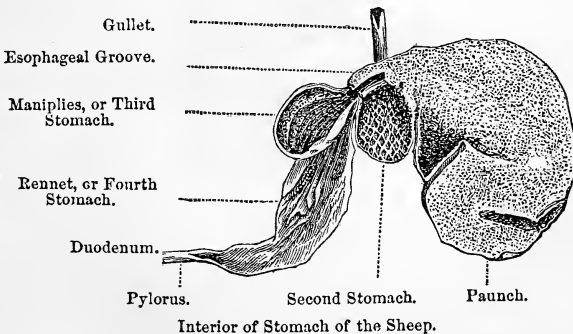
341. Stomach of Ruminants.—Mammals, as a general rule, have very simple stomachs, and particularly those which live upon animal food. But in those herbivorous ones which chew the cud, this organ consists of four cavities,

FIG. 190.



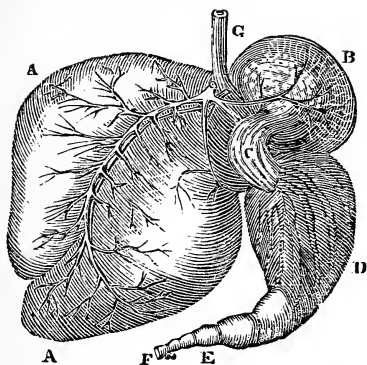
the Ingluvies or "Paunch," the Reticulum or "Honey Comb," the Omasum or "Many Plies," and the Abomasum

FIG. 191.



341. What is the number of stomachs in herbivorous animals? Give the names of each.

FIG. 192.



Stomach of the Ox. *A.* Paunch. *B.* Reticulum. *C.* Omasum. *D.* Abomasum. *E.* Pylorus. *F.* Duodenum. *G.* Esophagus.

or 'Red.' As the food enters the Inguvies, it is simply mixed with the fluid secreted by its coats, when it passes into the Reticulum, where it not only receives additional secretions, but is made into little "cuds" or "pellets," which, when the animal is at rest, are returned to the mouth for the purpose of re-chewing and mixing with the saliva.

After this process is

completed, they are sent into the Omasum, which cavity seems designed to prepare the food to enter the fourth stomach where the true process of digestion takes place. And it is from this fourth stomach or Abomasum, that the Rennet is taken from young calves, and used by cheesemakers for the purpose of coagulating the milk.

342. Reason of this Complex Stomach.—The probable reason of such a complicated stomach in these animals is that since they have such poor means of self-defense, they need to crop their food as quickly as possible, and then retire to a safe place to masticate it. And it is also partly owing to the fact that vegetable substances require a longer process for digestion than does animal food.

343. Length of Intestine.—The length of the Intestine depends as a general rule upon the food used by the animal,

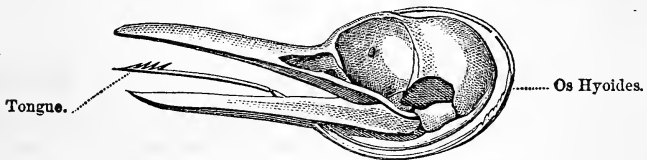
Give the process of chewing the cud in these animals. 342. What is one important reason for this complicated arrangement? 343. Upon what does the length of Intestine depend?

the vegetable feeders having a long tube, and the flesh feeders a short one, since animal food is so easy of stomach digestion, and the nutrient portion of it so readily taken up by the lacteals. Thus the ox has an alimentary tube fifteen or twenty times the length of the body, amounting in a full grown animal to 150 feet, the sheep one twenty-eight times its length, while many of the carnivora exhibit one only about three times the length of the body. The true Cetacea or Whale tribe are the only ones which do not have a marked distinction between the large and small intestine.

344. *The Liver.*—The Liver as in man is one of the largest organs in the body, and is much more divided into lobes in carnivorous than herbivorous animals. It is smallest and least divided in those animals with compound or ruminating stomachs.

345. *Bill of Birds.*—Birds are destitute of teeth, since the process of mastication is carried on in a certain portion of the alimentary canal. But the horny investment of the jaws known as the bill, is harder in birds of prey, and those

FIG. 193.

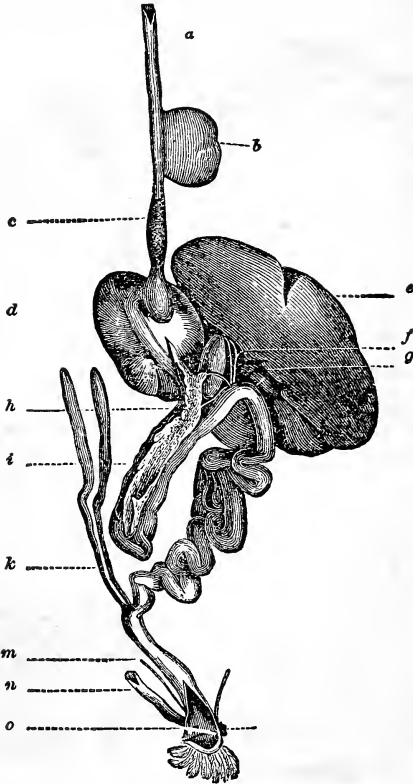


Head of the Woodpecker.

that feed on fruit and nuts, as Parrots, and in Woodpeckers. The bill, or rather mouth, of Ducks and Geese is lined by a tender membrane, in order that they may be partially

What is the length of the Intestine of the Ox? Of the Sheep? Give the proportional length of Intestine in Carnivorous Animals. 344. What difference in the Liver between flesh and herbivorous animals? 345. Why are Birds destitute of teeth? What Birds have the hardest bills? What peculiarity in the lining membrane of the mouth of Ducks, etc.?

FIG. 194.



Digestive Apparatus of Fowl. *a.* Esophagus. *b.* Crop or Ingluvies. *c.* Proventriculus. *d.* Gizzard. *e.* Liver. *f.* Gall-Bladder. *g.* Pancreas. *h.* Duodenum. *i.* Small Intestine. *k.* Caeca. *l.* Large Intestine. *m.* Ureter. *n.* Oviduct. *o.* Cloaca.

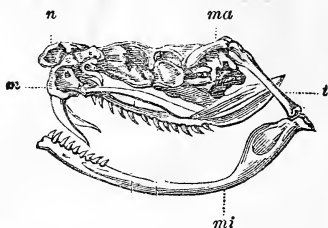
guided in the selection of their food from the soft mud by the sense of touch.

346. Stomach of Birds.—The Gizzard.—The true stomach of birds consists of two divisions. There are, how-

ever, three enlargements of the alimentary canal, all of which prepare the food for assimilation. The first of these is the "Ingluvies" or "Crop," where the food is softened by the mucous secretion of the lining membrane. Then as it passes along into the "Proventriculus," it receives the gastric juice from the gastric glands which line it. The second stomach, the "Gizzard," is round and flat and made up of powerful muscular fibres, except in birds of prey, where it is thinner in texture. In gallinaceous birds its lining membrane is of a horny consistency, which, with the powerful muscular fibres, render it an organ of mastication to granivorous birds. Gravel and angular stones are purposely swallowed by these birds to aid in the digestive or grinding process.

347. Teeth and Jaws of Reptiles.—Reptiles need teeth only to seize and retain their prey, since whatever food is taken by them, is swallowed without mastication, which is one reason why the jaws and throats of serpents are so very capacious. A peculiarity in their bony construction renders this possible, for the jaw is not made up of one or at most two pieces as in mammals, but of several segments, which readily move one upon another, as if with different articulations.

Fig. 195.



Head of the Rattlesnake. *mi*. Lower Jaw. *t*. Tympanic Bone. *ma*. Mastoid Bone. *m*. Upper Jaw.

348. The Tongue.—The Tongue is used as an instrument for the capture of prey by many reptiles. Frogs and Salamanders are able to thrust it out with great rapidity and

Give the names of each. Describe the Gizzard. Why are gravel and stones swallowed by granivorous birds? Which is the true stomach? 347. What is the only use of teeth in reptiles? State the reason why the jaws are so capacious. Of how many bones are they frequently made up? 348. Of what use is the tongue to some reptiles?

coil it upon insects or any other object. This property, together with the adhesive mucus found upon it, makes it for these animals a very serviceable apparatus in obtaining food.

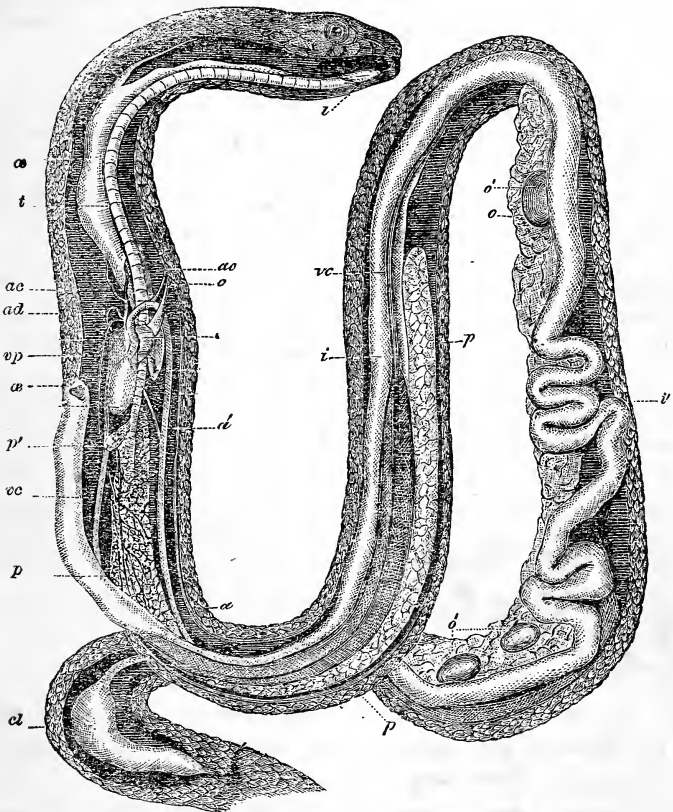
349. *Esophageal Teeth.*—In many animals of this description the *Esophagus* is lined with bony processes pointing downwards, called *Esophageal teeth*, which greatly aid in swallowing the large masses which they are accustomed to force into their stomachs.

350. *Stomach.*—*Length of Intestine.*—The *Stomach* seems to be only a dilatation of the *Intestine*. In many species it is divided into two cavities resembling those of a bird, (Fig. 196): the first a *Gizzard*, or an organ made up of stout muscular fibers, and the second a thin walled and secreting cavity. In *Crocodiles* it is round, and the muscular coat is very thick, in order to reduce to a digestible size the coarse food which it so greedily devours. The length of the intestine in most reptiles is about twice the length of the body; in *Lizards*, however, it is only about the same length as the body. A *cloaca* or additional *rectum* is sometimes found in these animals, as is the case among birds.

351. *Stomach and Intestine of Fishes*—In many *Fishes* the intestinal tube extends from the mouth directly through the animal without any enlargement for the stomach, or any convolutions, as is the case with all the animals thus far considered on this subject, and with which no organ of secretion is connected, except the liver. The intestinal canal, however, is generally more or less convoluted, and ordinarily it is short. In the *Shark* the stomach is parceled out by constrictions and

With what is it covered, that renders it more serviceable as an instrument of capture?
 349. What is said of *Esophageal teeth*? 350. Is the stomach a simple or complex cavity? What is the average length of intestine among reptiles? What is said of a *cloaca*?
 351. In what condition is the stomach found in most fishes? What peculiarity is met within the *Shark*?

FIG. 196.



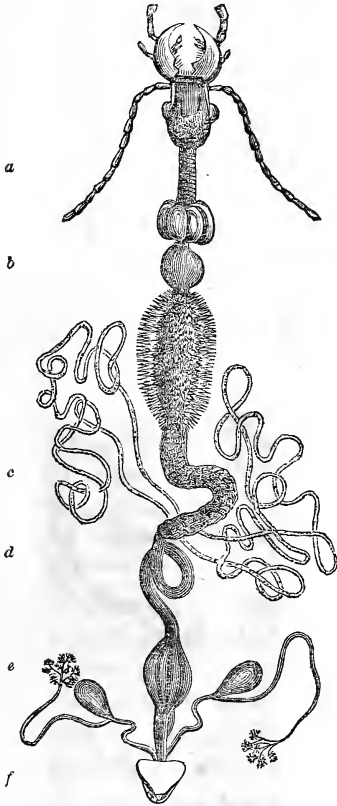
Anatomy of the Common Snake. *z*. Tongue. α . Esophagus. *i*. Stomach. *v'*. Small Intestine. *cl*. Cloaca. *f*. Liver. *o*. Ovary. *o'*. Eggs. *t*. Trachea. *p*. *p'*. Lungs. *vt*. Ventricle. *e*. *e'*. Auricles. *a*. *ad*. *a'*. Aorta. *ac*. Carotid Arteries. *v*. *vc*. Venæ Cavæ. *vp*. Pulmonary Vein.

inversions into several divisions with valve-like appendages between them.

352. Liver.—Fishes have usually a large soft Liver completely saturated with an oil. Its form is various, but is

often imperfectly divided into two lobes. The oil that is expressed from the liver of the Cod Fish, is often used with great efficacy in the early stages or symptoms of consumption.

FIG. 197.



Digestive Apparatus of a Beetle. *a.* Head. *b.* Crop and Gizzard. *c.* Biliary Vessels. *d.* Intestine. *e.* Secreting Organs.

353. Pyloric Appendages.

—In many fishes with bony skeletons there is found a curious set of gland-like organs called Pyloric appendages. They vary in number from two in the Plaice, to two hundred in the Mackerel, and always either encircle the pylorus, or are found near the upper end of the intestine. These appendages are invariably absent in those fishes which have an imperfectly formed stomach, and by some are considered as analogous to a Pancreas in function.

354. Salivary Glands.—

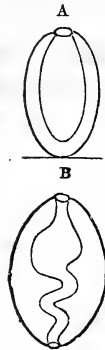
Salivary Glands are wanting in fishes, but their place is supplied by an increased development of the mucous glands of the mouth.

355. Digestive Organs in

the Invertebrates.—In the Polyps of the Radiate animals, we have the simplest form of digestive apparatus, viz., a simple sack, with a mouth to receive the food

and to disgorge the refuse, as is seen in Fig. 198, A. Other Polyps, however, have two openings in their stomach or sack, as shown in Fig. 198, B.

FIG. 198.

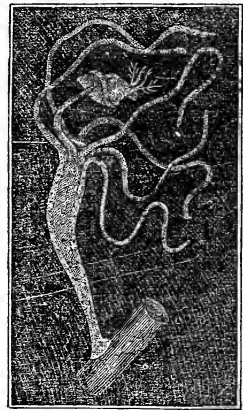


Digestive Apparatus of Unicellular Animals.

356. *The Hydra*.—Fig. 199, an unicellular animal, is an example where the simplest sort of digestive organs is exhibited. The animal is little

else than a gelatinous sac, and if it be turned inside out digestion will still go on. Thus, “notwithstanding the simplicity of its structure, this creature feeds not merely upon algæ, but upon young active animalcules, the young of crustaceans, etc. ; any one of these, when they happen to come in contact with one of the tentacular filaments, being usually retained by adhesion to it. As this filament shortens itself, all the surviving filaments apply themselves to this captive particle, so that it becomes gradually inclosed, and grad-

Fig. 199.



Hydra or Fresh Water Polyp. *a*. Entrance and Exit to Stomach.

gradually inclosed, and grad-

ually shortening, so as at last to bring the prey close to the surface of the body. The spot with which it is brought in contact, then slowly retracts, and forms at first a shallow depression, gradually becoming deeper and deeper, into which the prey sinks little by little, for some time, however, continuing to project from the surface. The depression at last assumes a flask-like form, by the drawing in of its margin, and finally its edges close together, and its prey is entirely shut in. This gradually passes to the center of the body, where its soluble parts are dissolved, whilst in the mean time its external portion recovers its pristine condition."

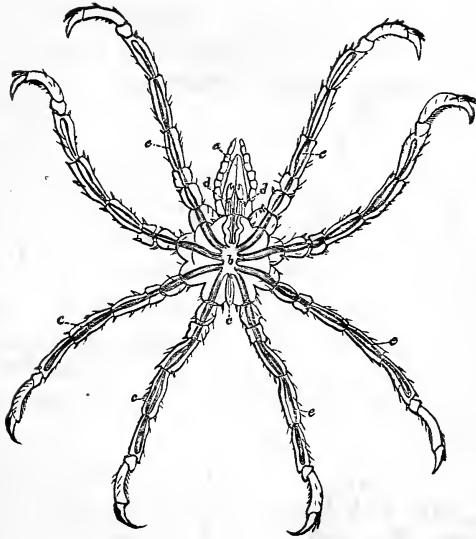
357. Other Radiates have an alimentary canal more complicated, having a stomach and cæcal appendages that appear to perform the office of a liver. Some of the Echinoderms have teeth; in the Echinidæ is a curious apparatus in the mouth called Aristotle's lantern.

358. Another form of the digestive apparatus consists of a central cavity, with branches extending through every part of the body. Fig. 200 shows this in one of the Articulated animals, an Arachnoid Crustacean, the *Ammothea pycnogonoides*. This arrangement is found in several other classes of the Invertebrates.

359. The Crustaceans are generally furnished with two upper jaws, called Mandibles, which move laterally; and behind these, two pairs of weaker and softer lower jaws, which are sometimes changed into suckers and legs. The higher branches are always provided with prehensile organs for seizing the food, which are arranged in pairs.

360. These are best seen in the Lobster, where they are enormously developed, projecting in front of the eyes a distance nearly equal to that of the length of the whole body, and each extremity is furnished with a powerful pair of pincers. Some of the higher Crustaceans have a sort of horny teeth implanted in the coats of the stomach which are worked by a

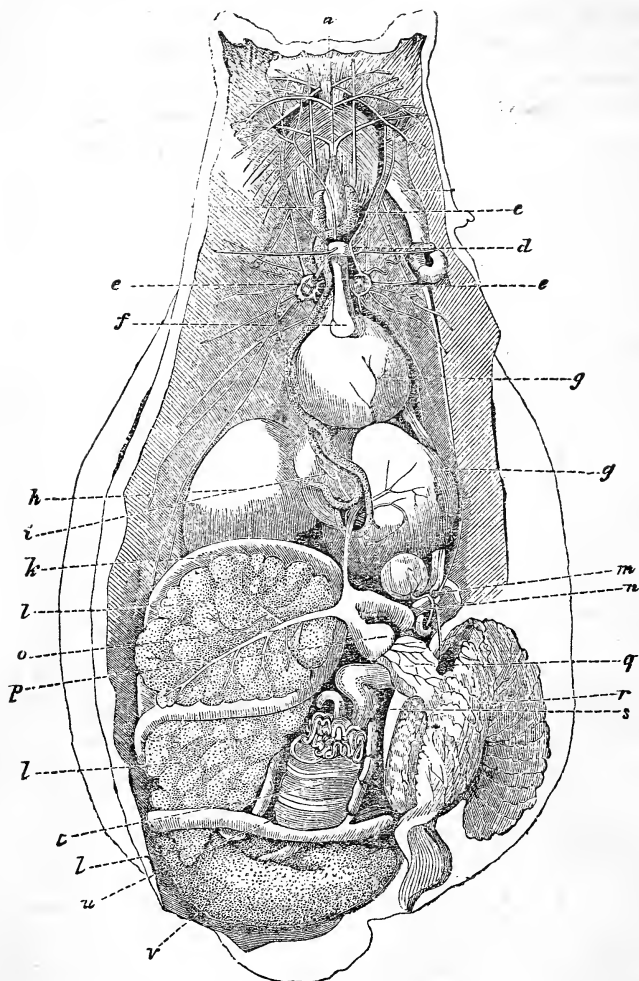
FIG. 200.



Digestive Organs of *Ammothea pycnogonoides* (Crustacean). *a.* Esophagus *b.* Stomach. *c.* Intestine. *d.* Digestive Cavity of the Jaws. *e.* Digestive Cavity of the Legs.

powerful set of muscles, which help in the reduction of the food. These teeth are found in the Lobster's stomach. The stomach of the Leech is very capacious, being nearly the size of the whole body. The same is essentially true of the common Earthworm, which is an Annelid. In many insects salivary glands are present, and in such cases they are placed at the commencement of the alimentary canal. The different parts of the alimentary canal in insects "may be properly distinguished in the following manner. The first portion is the Esophagus, muscular, occupying the three thoracic segments and often dilated at its posterior part into a crop (Ingluvies) and muscular gizzard (Proventriculus). Sometimes there is appended to the Esophagus a sucking stomach,

FIG. 201.



Aplysia (Mollusc) laid open to show the viscera. *a*. Esophagus. *c*. Salivary Glands. *d*. Cephalic Ganglion. *e*. Esophageal Ganglion. *f, g*. First Stomach or Crop. *h*. Third or True Stomach. *i*. Gizzard. *k*. Intestine. *l*. Liver. *m*. Posterior Ganglion. *n*. Aorta. *o*. Hepatic Artery. *p*. Ventricle of Heart. *q*. Auricle. *r, s*. Branchiæ or Gills. *u*. Lower Intestines. *v*. Ovary.

consisting of a more or less pedunculated thin walled vesicle, which is multiplied on itself when empty. The second portion consists of a stomach (ventriculus) in which the chyle is formed, and which is continuous at the point of insertion of the malpighian vessels with the third portion of the digestive canal. This third portion commences by a small and usually short ileum, which is followed by a colon larger and of variable length. This last often has a cæcum at its anterior extremity, and terminates posteriorly in a short, muscular Rectum."

"A considerable number of insects take no food during their perfect state, the object of their existence being only to accomplish the act of reproduction. Their jaws are often very rudimentary, and are fit neither for sucking nor for masticating."

361. The Annelida have sometimes quite complicated jaws, even as many as eight or nine, moving laterally. They have also salivary and hepatic glands, as have many other invertebrates. These are shown on Fig. 197, which represents the whole alimentary canal of an insect.

362. The Cephalopod Molluscs have a mouth, two horny jaws moving vertically in the pharynx, a tongue, an œsophagus, a stomach, a pylorus, and an intestinal canal.

363. In the Cephalophora the jaws move laterally for the most part. In the whole class we find a biliary apparatus and generally salivary glands. Fig. 201 shows the digestive organs of a Gasteropod, the *Aplysia*. Nearly all the Cephalophora have a longer or shorter fleshy mass attached to the base of the pharynx that is comparable to a tongue. It has a longitudinal groove in it, and is sometimes included in a sheath. It is always covered with horny denticulated plates and spines, which are very delicate, and arranged in quite elegant longitudinal and transverse rows. The points of these spines turn backward, which aids greatly in swallowing.

364. In some families of the Entozoa—the Cystici, the Cestodes and Acanthocephali—there is no mouth nor proper intestinal canal, but there are vessels for the circulation of nourishment which is received directly through the sides of the body, on the principle of endosmosis.

CHAPTER FOURTH.

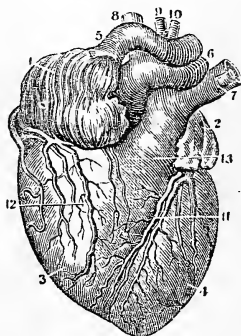
THE CIRCULATING SYSTEM.—ANGIOLOGY, OR HISTORY OF THE ORGANS OF BLOOD CIRCULATION.

DEFINITIONS AND DESCRIPTIONS.

365. The Circulatory Organs.—The organs composing this system are the Heart, Arteries, Veins, and Capillaries, and are mainly tubes of various diameters and a hollow organ, with the double office of receiving and propelling the blood.

366. The Heart.—The Heart, or central engine of circulation, is located in the thorax or chest, resting by its lower surface on the diaphragm, and somewhat to the left of the middle line of the body. It is of a conical form, made of animal muscular fiber, the fibers crossing themselves in at least three directions; and it is a singular fact that

FIG. 202.



An Anterior view of the Heart in a Vertical Position, with its Vessels injected. 1, Right Auricle. 2, Left Auricle. 3, Right Ventricle. 4, Left Ventricle. 5, Descending Vena Cava. 6, Aorta. 7, Left Pulmonary Artery. 8, The Arteria Innominata. 9, Left Primitive Carotid. 10, Left Sub-Clavian Artery. 11, Anterior Cardiac Vessels in the Vertical Fissure. 12, Posterior Vessels from the Transverse Fissure. 13, Main Trunk of the Pulmonary Artery.

FIG. 203.



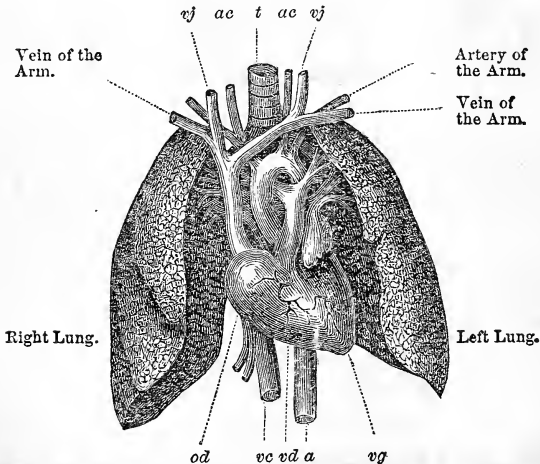
many of the fibers of the heart anastomose, or join with each other in many places, as is seen in Fig. 203. The heart is a double organ, one side being called the arterial and the other the venous, or left and right hearts, since the former receives and propels the pure or arterial blood, while

Anastomosing Fibers of the Human Heart.

the latter circulates venous blood. Again, each of the two sides or hearts are divided into an auricle and a ventricle. Each of these four cavities will ordinarily contain about three fluid ounces, making the whole heart to contain nearly a pint.

367. The Auricles and Ventricles.—The Auricles are the uppermost cavities of the heart, and are somewhat smaller

FIG. 204.



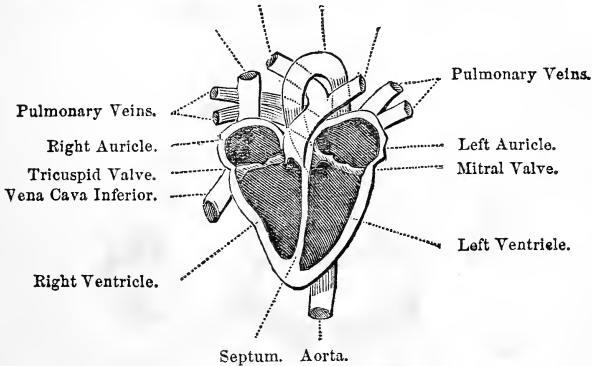
Lungs, Heart, and Principal Vessels in Man. *od*, Right Auricle. *vd*, Right Ventricle. *vg*, Left Ventricle. *a*, Aorta. *ac*, Carotid Arteries. *vc*, Vena Cava. *t*, Trachea. *vj*, Jugular Veins.

What are its shape, size, and four cavities called? What is the capacity of an adult heart?

than the Ventricles, or lower ones. The auricles also have the thinnest walls, and are capable of considerable dilatation, since by a sudden effort of the body the blood is liable to be sent in great quantities to the heart, and the veins would be in danger of rupture were there no elasticity in the receptacle. The thickened walls of the ventricles give increased power of

FIG. 205.

Vena Cava Sup. Art. Pulm. Aorta. Art. Pulm.



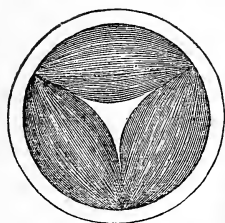
Theoretical Section of the Heart in Man.

contraction. This is needed because the ventricles drive the blood *from* the heart, and the auricles receive it on its return. The right ventricle, however, propels the blood only *to* the lungs, while the left ventricle sends it to all parts of the body except the lungs. The left auricle receives only the blood from the lungs, while the right auricle receives it from all the other parts of the body.

368. Valves of the Heart.—Between the auricles and ventricles are peculiar forms of muscular and tendinous fibers, resembling cords and pillars, that are termed valves, making a sort of curtain to allow the flow of blood from the auricles to the ventricles, but not in the opposite direction. At the

367. Give the essential differences between the auricles and ventricles. Why does the left ventricle need the thickest walls? 368. Describe the valves which lie between the auricles and ventricles.

Fig. 206.

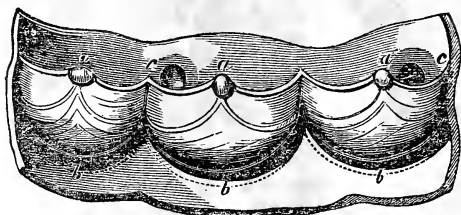


Semi-lunar Valves of the Heart closed.

point where the arteries are given off from each ventricle are found (in each) three crescent-shaped folds of semi-cartilaginous tissue called Semi-lunar Valves, to allow the motion of blood in an outward direction, but to prevent the return, which is called regurgitation.

369. Pericardium.—In addition to the fasciæ and fatty matter which immediately invest the heart, this organ is enclosed in another membrane in the form of a shut sac, a fibro-serous membrane called

Fig. 207.

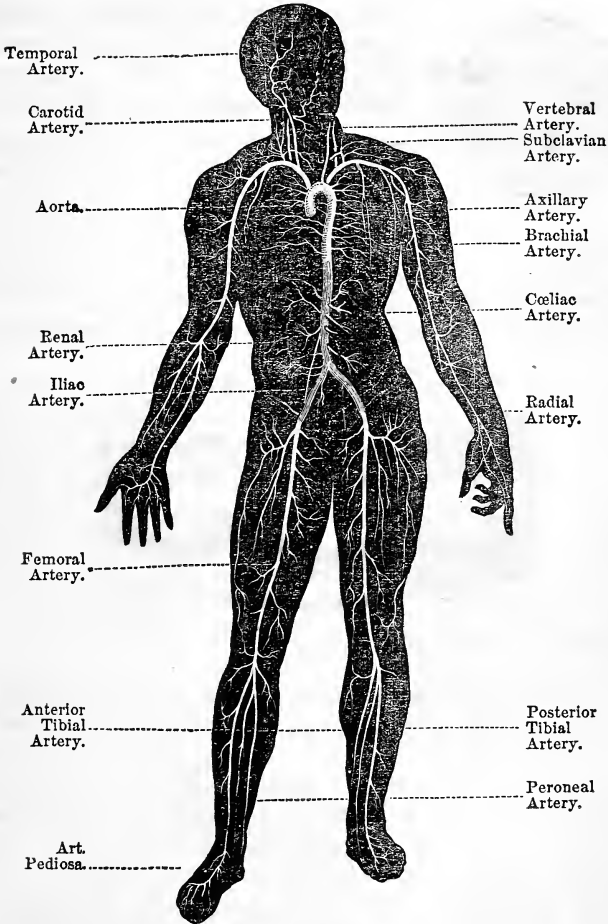
Semi-lunar Valves of the Aorta laid open. *a*, Corpus Arantii on the Free Border. *b*, Attached Border. *c*, Orifices of Coronary Arteries.

the Pericardium (meaning about the heart). This contains a small quantity of a fluid like water, so that the heart actually floats in a liquid, and does not rest firmly upon any hard surface. The pericardium not only exists as a loose sac about the heart, but it is reflected upon it where the vessels are given off; covering it in the same manner as the fasciæ cover and protect the muscles.

370. Arteries—Their Coats.—The Arteries are tough and cylindrical tubes which convey the blood from the heart to the different parts of the body. They are made up of three mem-

Describe the Semi-lunar Valves and their location. 369. What is the sac called that surrounds the heart? What fluid does it contain? How much of it is there? Is the pericardium attached at all to the heart? 370. Of how many coats are the arteries composed?

FIG. 208.

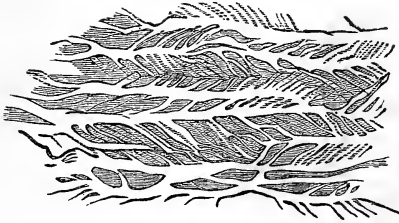


Arterial System in Man.

branes, of which the middle one deserves especial attention. This is an elastic coat composed of yellow fibrous tissue (Fig. 209), in order, as we shall presently see, to aid in the circu-

Describe each one and their peculiar value.

FIG. 209.



Highly Magnified Portion of the Middle Coat of the Arteries.

lation of the blood. The inner one is smooth and of a serous character, for the ready passage of the blood over it. The arteries (all above $\frac{1}{24}$ th inch in diameter) are nourished by a capillary net-work which is made from ad-

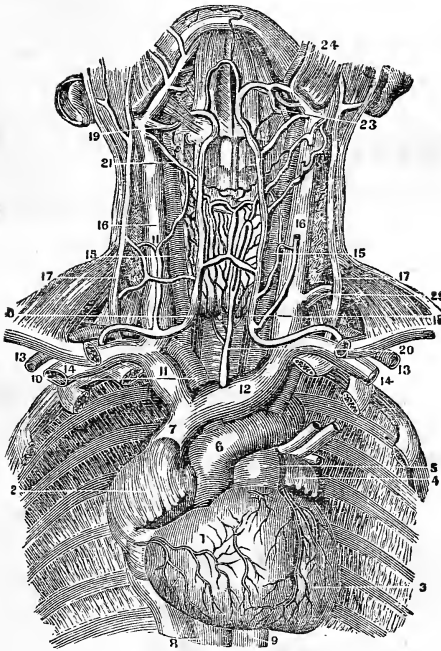
joining blood-vessels. Nerves are distributed to some arteries, but ordinarily they only accompany them.

371. The Aorta.—The arteries sent to every portion of the body from the left ventricle proceed from one trunk, called the Aorta, meaning a starting-point. It is nearly an inch in diameter, and ascends in a perpendicular direction for about two inches, when it makes a curve upon itself, and descends through the thorax and abdomen until it reaches the fourth lumbar vertebra, when, as is the case with most of the large arteries, it divides into two branches of equal size. Between the curve or arch of the aorta and the heart no branches are given off, but from the summit of this arch to the subdivision in the abdomen a great number of branches are distributed to the different portions of the chest and abdomen.

372. Description of Particular Arteries—Innominata—Carotid—Subclavian—Axillary—Brachial—Ulnar Radial—Palmar Arch.—The first branch arising from the summit of the aortic arch is the large one called the Innominata, or nameless artery. Next comes the Carotid, and both distribute themselves to the head and upper extremities.

371. What is the Aorta? What does the word aorta mean? Give its course till it subdivides. Where does it divide into the common iliaes? 372. Where are the Innominata Arteries? The Carotid?

FIG. 210.

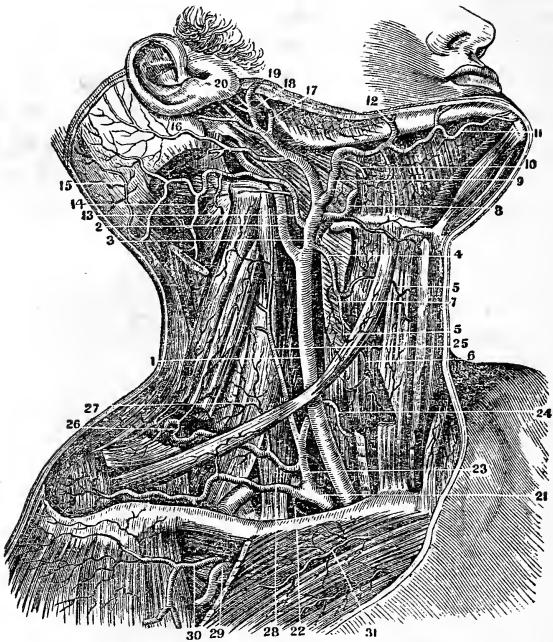


A View of the Heart, with the Great Vessels of the Neck in Situ. 1, Right Ventricle of the Heart. 2, Right Auricle. 3, Left Ventricle. 4, Left Auricle. 5, Pulmonary Artery. 6, Arch of the Aorta. 7, Descending Vena Cava at its entrance into the Right Auricle. 8, Ascending Vena Cava. 9, Thoracic Aorta. 10, Arteria Innominata. 11, Right Brachio-Cephalic Vein. 12, Left Brachio-Cephalic Vein. 13, Section of the Sub-Clavian Artery. 14, Section of the Sub-Clavian Vein. 15, 15, Primitive Carotid Arteries. 16, 16, Internal Jugular Veins. 17, 17, External Jugular Veins. Between these Veins is seen the Section of the Sterno-Cleido-Mastoid Muscle. 18, The Trunk formed by the Superficial Cervical Veins, known sometimes as the Anterior Jugular Vein. 19, A Branch from it to the Facial. 20, Main Trunk from the Inferior Thyroid Veins. 21, Superior Thyroid Vein. 22, Transverse Cervical Artery and Vein. 23, Lingual Artery and Vein. 24, Facial Artery and Vein.

The Innominata on the right very soon becomes the Sub-clavian, after which the corresponding arteries of both arms receive the same name. The Sub-clavian Artery, as its etymology implies, lies directly beneath the clavicle until it reaches the axilla, or arm-pit, where it receives the name of

The Sub-clavian? The Axillary?

FIG. 211.



A View of the Arteries of the Neck and Shoulder. 1, Primitive Carotid Artery. 2, Internal Carotid Artery. 3, External Carotid Artery. 4, The Superior Thyroid Artery. 5, Branches to the Muscles. 6, Main Branch to the Gland. 7, Inferior Pharyngeal Artery. 8, Lingual Artery. 9, Facial Artery. 10, Its Branches to the Sub-Maxillary Gland. 11, Sub-Mental Branch. 12, Principal Branch of the Facial as it goes over the Jaw. 13, Occipital Artery. 14, Branches to the Muscles on the Back of the Neck. 15, Main Trunk to the Occiput. 16, Posterior Auricular Artery. 17, A Branch cut off, which goes to the Parotid Gland. 18, Origin of the Internal Maxillary Artery. 19, Origin of the Temporal Artery. 20, Origin of the Anterior Auricular. 21, The Sub-Clavian. 22, Origin of the Internal Mammary. 23, Trunk of the Inferior Thyroid, from which arise in this subject the Anterior and Posterior Cervical Arteries. 24, Branch of the Inferior Thyroid going to the Thyroid Gland. 25, Anterior Cervical going up the Neck. 26, Posterior or Transverse Cervical. 27, Branches to the Scaleni and Levator Scapulae Muscles. 28, The Superior Scapular Artery. 29, The Thoracica Superior of the Axillary Artery. 30, A Branch to the Deltoid. 31, Recurrent Branches of the Intercostals.

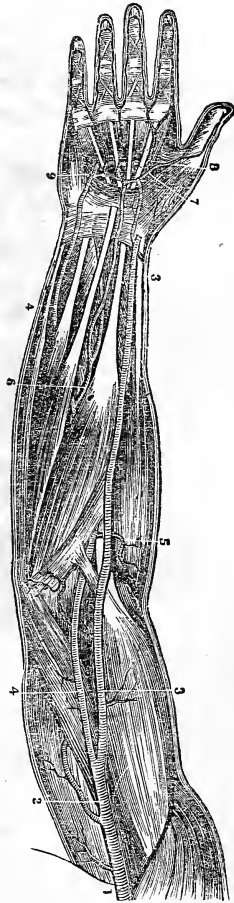
Axillary Artery. Then as it passes along the inner side of the humerus it is called the Brachial, until it has passed beyond the inner side of the elbow, where it is divided into the Ulnar and Radial, corresponding in position and direction to

Where are the Brachial, Ulnar, and Radial Arteries ?

the ulna and radius. Sometimes, however, the branching takes place higher up, as is seen in cut 212. When these have fairly passed the wrist, they both join again in an artery which describes a curve at the base of the metacarpus crossing the palm of the hand, and called the Palmar Arch. Small branches are given off from this which supply the different parts of the hand, including the fingers and thumb.

373. Distribution of the Carotids—Vertebral—Circle of Willis.—The common Carotid Arteries, one on each side of the neck, pass upwards from the innominate and subclavian nearly as far as the angle of the jaw, when they divide into the internal and external carotids, the latter furnishing blood to the face, and the former to the brain and back part of the head. The Vertebral Artery is also given off from the sub-clavian, which, passing backward, enters the spinal column at the sixth cervical vertebra, and

FIG. 212.

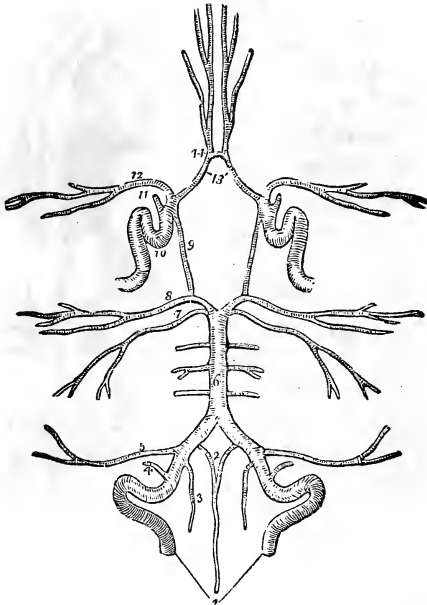


Arteries of the Arm. 1, Termination of the Axillary Artery. 2, The Brachial Artery. 3, 3, Radial Artery. 4, 4, Ulnar Artery. 5, A Recurrent Branch. 6, Anterior Interosseous Artery. 7, Superficial Palmar Arch formed by the Ulnar Artery. 8, Deep-Seated Palmar Arch. 9, The Anastomosis of the two Arteries, much enlarged.

What is the Palmar Arch? 373. Give the branches of the Carotid as it passes upward to the head.

passing through a foramen or opening in the transverse process of each of these vertebræ, at last reaches the posterior portion of the brain. This artery in the brain meets with the terminal branches of the internal carotid, so that the blood can easily reach the brain from either direction. By this arrangement, if, from pressure or accident, the flow of blood to the brain in either of these channels should be obstructed, the other would supply it; for sensation and consciousness

FIG. 213.



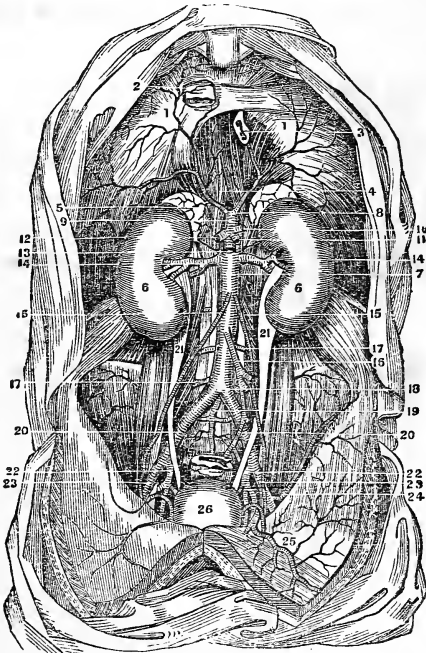
Circle of Willis. 1, Vertebral Arteries. 2, 3, Anterior and Posterior Spinal Arteries. 4, Posterior Meningeal Artery. 5, Inferior Cerebellar. 6, Basilar. 7, Superior Cerebellar. 8, Posterior Cerebral. 9, Branch of Carotid. 10, Internal Carotid. 11, Ophthalmic Artery. 12, 13, Cerebral Arteries. 14, Anterior Communicating Artery.

entirely cease if the brain be deprived of its arterial blood. This arrangement is called the "Circle of Willis" from its discoverer.

What arteries does the Vertebral communicate with in the brain? What is the service of this arrangement?

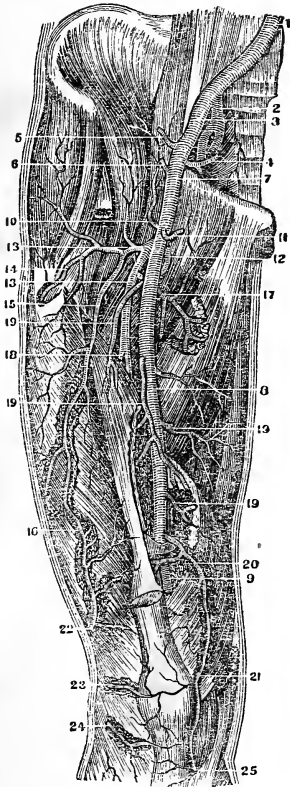
374. Thoracic Aorta—Abdominal Aorta—Celiac Axis—Gastric, Hepatic, Splenic, Renal, Mesenteric, and Lumbar Arteries.—After the aorta fairly commences its descent—called the Thoracic Aorta—several small branches are given off from it which send nourishment to the heart and lungs, and next a pair which are distributed to the diaphragm. Then

FIG. 214.



A View of the Abdominal Aorta and its Branches. 1, 1, The Diaphragm. 2, Foramen Quadratum and Section of the Ascending Vena Cava. 3, Foramen Esophageum and Section of the Esophagus. 4, Foramen Aorticum in the Crura of the Diaphragm. The Phrenic arteries are seen going to the Diaphragm. 5, Capsulæ Renales. 6, The Kidneys. 7, Abdominal Aorta. 8, Phrenic Arteries. 9, Celiac—giving off. 10, The Splenic. 11, The Gastric. 12, The Hepatic. 13, Section of Superior Mesenteric. 14, Emulgent Arteries. 15, Spermatic Arteries. 16, Inferior Mesenteric. 17, 17, Lumbar Arteries. 18, Division of the Abdominal Aorta. 19, Its last Branch—the Middle Sacral. 20, Primitive Iliacs. 21, Ureters—in their Position to the Arteries. 22, Internal Iliacs. 23, External Iliacs. 24, Circumflexa Ilii. 25, Distribution of the Epigastric. 26, Bladder distended with Urine. The Vesical Arteries are seen near it.

FIG. 215.



A Front View of the Femoral Artery, as well as of the External and Primitive Iliacs of the Right Side.

1, Primitive Iliac Artery. 2, Internal Iliac Artery. 3, External Iliac Artery. 4, Epigastric Artery. 5, Circumflexa Ilii Artery. 6, Arteria Ad Cuntem Abdominis. 7, Commencement of the Femoral just under the Crural Arch. 8, Point where it passes the Vastus Internus Muscle. 9, Point where it leaves the Front of the Thigh to become Popliteal. 10, Muscular Branch to the Psoas and Iliacus. 11, External Pudic Artery cut off. 12, Origin of the Internal Circumflex. 13, Profunda Femoris. 14, Muscular Branch. 15, 16, Artery to the Vastus Externus Muscle. 17, Artery to the Pectineus and Adductors. 18, First Perforating Artery. 19, 19, Muscular Arteries. 20, 21, Anastomotica. 22, Superior External Articular. 23, Middle Articular. 24, Inferior External Articular. 25, Inferior Internal Articular.

we meet with a large trunk given off just below the diaphragm, about half an inch in length, called the Cœliac Axis, which gives origin to the Gastric artery supplying the stomach, the Hepatic, running to the liver, and the Splenic furnishing blood for the spleen. Below this we find the Renal arteries, supplying the kidneys, and the Superior and Inferior Mesenteric Arteries, which give blood to the intestines, and the Lumbar Arteries, terminating in the external muscles of the abdomen.

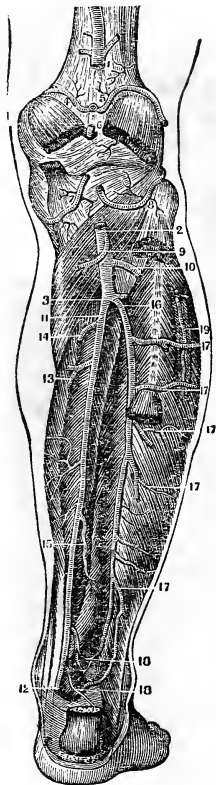
375. Iliac Arteries—Femoral, Popliteal, and Tibial Arteries—Dorsalis Pedis.—As already mentioned, the aorta divides into two branches opposite the fourth lumbar vertebra, for the supply of the lower extrem-

Describe the Cœliac Axis. Where are the Gastric, Hepatic, Splenic, Renal, and Lumbar Arteries?

ities. These are the common iliacs, from being near the ilium, and each of them soon subdivides into the External and Internal Iliac, the former of which supplies the greater portion of the leg with blood. As soon as it passes over the pubis it becomes the Femoral Artery, which at first is quite external, lying just beneath the skin and upon the pubis; but as it passes down the femur it plunges deeper and deeper into the soft parts until it appears behind the knee, where it receives the name of the Popliteal Artery. This is only a few inches in length, and at the upper extremity of the tibia divides into the Anterior and Posterior Tibial Arteries. The former runs along the inner side of the tibia and over the tarsal bones, until it reaches the metatarsus, when it becomes the Dorsalis Pedis, which gives off branches to

Lower End of the same Artery on the Popliteus Muscle. 3, Point of Bifurcation into the Posterior Tibial and Peroneal. 4, Superior Internal Articular Artery. 5, Superior External Articular Artery. 6, Middle Articular Artery. 7, Inferior Internal Articular Artery. 8, Inferior External Articular Artery. 9, Branch to the Head of the Soleus Muscle. 10, Origin of the Anterior Tibial Artery. 11, Origin of the Posterior Tibial Artery. 12, Point where it passes behind the Annular Ligament to become the Plantar. 13, 14, 15, Muscular Branches. 16, Origin of the Peroneal Artery. 17, 17, Muscular Branches. 18, 18, Anastomosis of the Posterior Tibial and Peroneal Arteries near the Heel. 19, Muscular Branch from the Anterior Tibial.

FIG. 216.



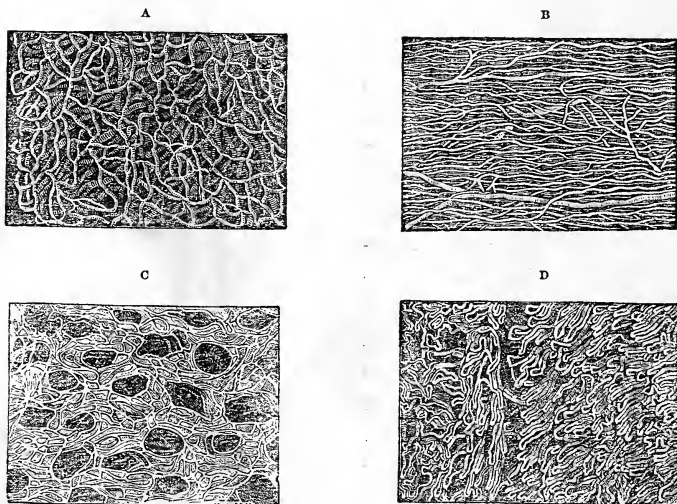
A View of the Arteries on the Back of the Leg. The Muscles have been removed so as to display the Vessels in their whole length. 1, The Popliteal Artery, cut off so as to show the Articular Arteries. 2,

875. What do the common Iliac Arteries become as soon as they cross the pubis? Give the location of the Femoral, Popliteal, Tibial, and Dorsalis Pedis Artery.

each of the toes, and supplies the upper part of the foot with blood. The Posterior Tibial Artery follows upon the back side of the leg a corresponding course to the anterior tibial, and supplies the sole of the foot and toes with blood.

376. Capillaries.—The arteries just described are a few only of the principal ones, since at nearly every inch of their course larger or smaller vessels are given off according to the

FIG. 217.



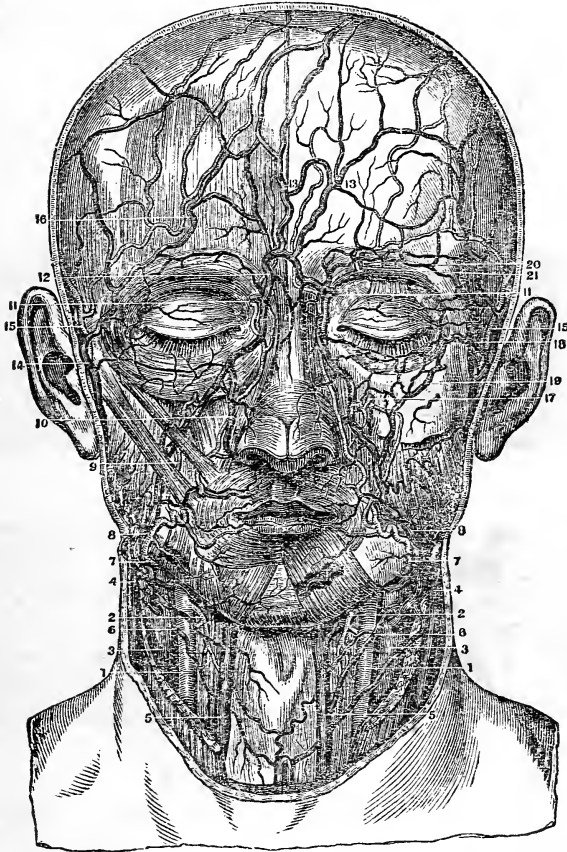
Varieties of Capillaries. A, Those around Fat Cells. B, In Muscle. C, In Mucous Membrane. D, Skin of Finger.

nature of the part to be supplied with blood, and, with a few exceptions, such as the one in the head (circle of Willis), they all terminate in minute vessels called Capillaries.

377. Diameter of Capillaries—Functions Performed in them.—These are minute tubes $\frac{1}{50000}$ th to $\frac{1}{60000}$ th of an inch in diameter, and are always the terminations of arteries. They are of a uniform size, and very regular in the distribu-

376. How do nearly all the arteries terminate? Where is the only exception? 377. State the diameter of the Capillaries. What of their uniformity?

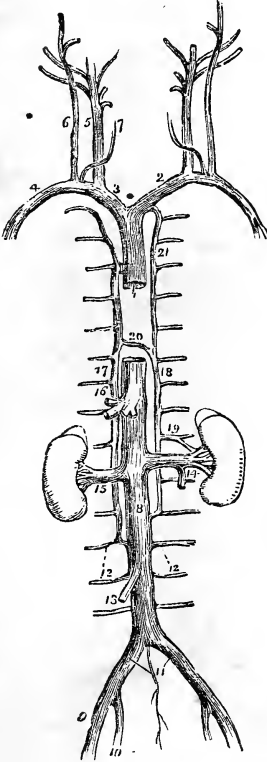
FIG. 218.



A Front View of the relative Positions of the Veins and Arteries of the Face and Neck. On the Right side the Superficial Vessels are seen, and the Deep-seated ones on the Left. 1, Primitive Carotid Arteries. 2, Superior Thyroid Arteries. 3, Internal Jugular Veins. 4, External Jugular Veins. 5, A Branch known as the Anterior Jugular Vein. 6, Superior Thyroid Veins. 7, Facial Arteries. 8, Facial Veins. 9, Zygomatic Branch of the Facial Artery. 10, Nasal Branch of the Facial Vein. 11, Anastomosis of the Facial Artery and Vein with the Ophthalmic Artery. 12, Venous Arch above the Nose. 13, Frontal Vein. 14, Temporal Vein. 15, Temporal Artery. 16, Frontal Branches of the Temporal Artery and Vein. 17, Infra-Orbital Vessels. 18, Sub-Aponeurotic Branch of the Temporal Vein. 19, 20, Venous Anastomosis around the Eye-Lids. 21, Frontal Branches of the Ophthalmic Vessels of Willis.

tion of their branches, without any increase in their diameter. The only exception to this is where red blood is not required for the nourishment of the parts; as in the white of the eye, the finger nails, the tendons, etc., where the capillaries are too small to allow the corpuscles of blood to pass through them. And yet in many of the capillaries we find their size to be so small that the corpuscles could not, if unyielding, pass through. But this is readily accomplished in most cases by the flexibility of the corpuscle, which permits itself to be doubled up to such an extent that it will easily pass through a tube much smaller than its normal diameter. In the capillaries the important processes of secretion, nutrition, and the production of a portion of animal heat take place; so that there is no place in the whole body except the outer coat of the eye, the tendons, the nails, and white portions of the body generally where true capillaries are not found.

FIG. 219.



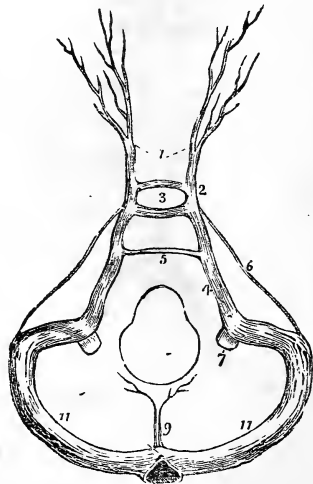
A View of the Veins of the Trunk and Neck. 1, The Descending Vena Cava. 2, The Left Vena Innominata. 3, The Right Vena Innominata. 4, The Right Sub-Clavian Vein. 5, The Internal Jugular Vein. 6, The External Jugular. 7, The Anterior Jugular. 8, The Inferior Vena Cava. 9, The External Iliac Vein. 10, The Internal Iliac Vein. 11, The Primitive Iliac Veins. 12, 12, Lumbar Veins. 13, The Right Spermatic Vein. 14, The Left Spermatic Vein. 15, The Right Emulgent Vein. 16, The Trunk of the Hepatic Veins. 17, The Vena Azygos. 18, The Hemi-Azygos. 19, A Branch communicating with the Left Renal Vein. 20, The Termination of the Hemi-Azygos in the Vena Azygos. 21, The Superior Inter-Costal Vein.

Where are true capillaries not found? What takes place in them?

378. **The Veins—Their Coats—Their Volume.**—The Veins carry the blood from all parts of the body to the heart. Like the arteries, they have three coats, and the larger veins follow the same general course as the large arteries. The smaller veins, however, are much more numerous than the smaller arteries, and are most abundant just beneath the skin. The whole volume of the veins may be regarded as a large cone, with the base at the surface of the body and the apex at the heart, so that in these vessels the blood is continually flowing faster and faster, in consequence of the fluid coming into a larger channel from small extremities, while the reverse happens in the arteries. The veins are much thinner in structure than the arteries, so that after death they most usually collapse. (See Fig. 218, p. 215.)

379. **Location of the larger Veins—Sinuses.**—As already mentioned, the larger veins usually lie near the larger arteries. Both also frequently have the same names. But there are several remarkable exceptions to this, as in the vessels of the brain. Here are but few veins, but several sinuses or channels. These are canals excavated in the dura mater of the brain with this membrane for an outer coat, and the serous layer of the true veins for an inner coat. These run in different directions on the inside of the skull, and

Fig. 220.



Sinuses of the Base of the Skull. 1, Ophthalmic Veins. 2, Cavernous Sinus. 3, Circular. 4, 6, Inferior Petrosal. 5, 9, Occipital Sinuses. 7, Internal Jugular Vein.

378. What course does the blood take in the veins? Give the coats of the veins. What is the relative proportion of small veins and small arteries? What is said of their aggregate volume? 379. Where are the larger veins usually found? What are Sinuses, and where are they found?

most of them empty into the great veins of the neck. Their probable service is to afford a free passage of blood from the brain, even if by excess of arterial action this organ should be overcharged with blood.

380. Portal System—Use of the Portal System.—Another apparent exception to the ordinary system of veins is seen in what is called the Portal System. This comprises those vessels which receive their blood from the intestinal canal, the stomach, and the spleen. As these small vessels unite into a larger trunk, instead of passing directly to the heart, they form what is called the Portal Vein, which empties itself into the liver. This vein ramifies into every part of the liver, where the blood is again collected by a series of vessels which unite into several trunks, called the Hepatic Veins, and which convey the blood to the heart. The design of this arrangement is not certainly known as yet, although it is probable that the blood which returns from the alimentary canal is not fitted to enter the general circulation until it has gone through some change in the liver.

FIG. 221.



Vein laid open to show the Valves. *a*,
Vein. *b*, Valves.

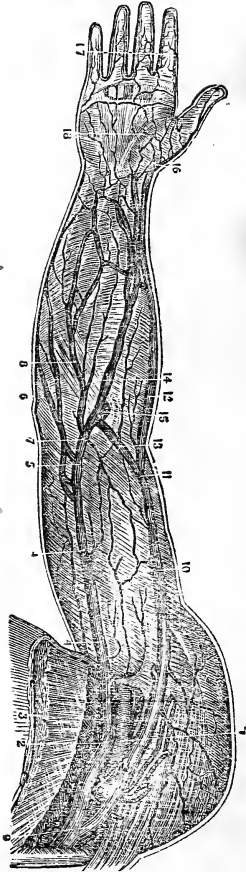
381. Origin of the Veins
—Valves—Their Discoverer.
—The Veins all take their origin in the capillary vessels in every part of the body except those of the stomach, and in number and length of tube greatly exceed the vessels of the arterial system. In the lining membrane of the veins, also, we find a peculiarity not presented in the arteries. This is the presence of folds, so that pouches or bags are formed, which readily suffer the flow of blood towards the

Of what especial service are they? 380. Describe the Portal System. What is the probable use of so marked an exception to the general circulating System? 381. Where do the Veins take their origin? What is said of the Valves of the Veins?

heart, but almost entirely prevent its passage in an opposite direction. They act in the same manner as valves in machinery, although with no loss from friction, and consequently no necessity of a lubricating fluid. It was the discovery of these valves in the veins which led Harvey, an English physician, to the greater discovery of the circulation of the blood. He inferred that the blood could pass in but one direction through the veins, and consequently in the opposite direction through the arteries.

382. Inosculation — Use of Anastomosis.—The arteries and veins open into each other (*i. e.*, their own vessels) very frequently, allowing a ready flow of blood from one vessel to the other, even if the flow does not happen to be in the most favorable direction from the center of circulation to the

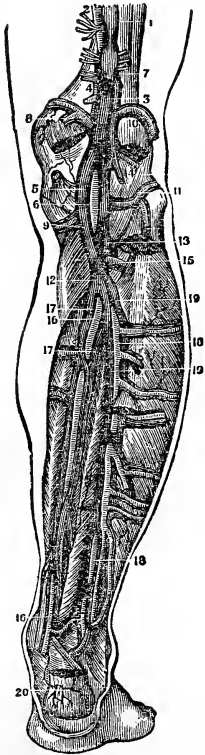
FIG. 222.



The Superficial Veins on the Front of the Upper Extremity. 1, Axillary Artery. 2, Axillary Vein. 3, Basilic Vein where it enters the Axillary. 4, 4, Portion of the Basilic Vein which passes under the Brachial Fascia—a portion of the Vein is freed from the Fascia. 5, Point where the Median Basilic joins the Basilic Vein. 6, Points to the Posterior Basilic Vein. 8, Anterior Basilic Vein. 9, Point where the Cephalic enters the Axillary Vein. 10, A portion of the same Vein as seen under the Fascia; the rest is freed from it. 11, Point where the Median Cephalic enters the Cephalic Vein. 12, Lower portion of the Cephalic Vein. 13, Median Cephalic Vein. 14, Median Vein. 15, Anastomosing Branch of the Deep and Superficial Veins of the Arm. 16, Cephalica-Pollicis Vein. 17, Sub-Cutaneous Veins of the Fingers. 18, Sub-Cutaneous Palmar Veins.

Who discovered the circulation of the blood?

Fig. 223.



The Arteries and Deep-seated Veins on the Back of the Leg. 1, Popliteal Vein. 2, Popliteal Artery. 3, 4, Vein and Artery in their relative Position on the Back of the Knee-Joint. 5, Popliteal Vein on the inner Side of the Joint. 6, Popliteal Artery without and beneath it. 7, Extremity of Saphena Minor Vein. 8, 9, Internal Articular Vessels, both Arteries and Veins. 10, 11, External Articular Vessels, both Arteries and Veins. 12, Junction of the Peroneal and Posterior Tibial Veins. 13, A Venous Branch from the Anterior Tibial Vein. 14, A Vein from the Gastrocnemius. 15, Anterior Tibial Artery coming through the Interosseous Ligament. 16, Posterior Tibial Artery. 17, Its two Venæ Comites. 18, Peroneal Artery. 19, Its two Venæ Comites. 20, Vessels on the Heel.

extremities. This relation of parts is called Inosculation or Anastomosis. This arrangement gives a plentiful supply of blood to every part of the body, if, by wound or pressure, the ordinary channel of blood to any part should be obstructed or completely closed up. Inosculation is most abundant in the veins and superficial arteries, since these are most liable to be thus impeded.

383. The Blood — Microscopic Structure — Plasma or Serum — Red Corpuscles — White Corpuscles — Proportion of one to the other. — The blood of the human system amounts to about eighteen pounds, or nearly ten quarts. It has a specific gravity a little greater than that of water, is of a bright scarlet color if drawn from an artery, or dark purple if taken from a vein, with a taste slightly alkaline, and an odor resembling that

382. What is meant by Inosculation or Anastomosis? What is the service of anastomosis? In what vessels is it most abundant? 383. How much blood is there in a human adult? State its color and odor.

of the breath of the animal from which it is taken. It penetrates every solid tissue of the system, as may be known by puncturing any part of the body with even a pin, when blood is sure to follow. If it be examined with a microscope when freshly drawn, it appears to be made up of a transparent liquid called the Serum or Plasma, and a number of minute circular bodies, mostly of a red color, called corpuscles, or minute bodies.

This fluid is found, on analysis, to be made up of water, albumen, fibrin, and several salts, some of which are found in crystals, as is seen in the cut. After it has been drawn from the body a considerable time, it separates into a thickened mass called Coagulum, made up of fibrin and the corpuscles, while the serum with the albumen still remains as a transparent liquid.

The Red Corpuscles prove to be flattened discs with both surfaces slightly concave, and measuring about $\frac{1}{3200}$ th of an inch in diameter, and are in reality nothing but a cell, that is a bag or sac containing a fluid composed of the two proximate principles globuline and hematine.

Besides the red corpuscles, there exists another kind in the blood known as the White or Colorless Corpuscles. They are by no means so abundant, when the body is

FIG. 224.



Crystals from Human Blood.

FIG. 225.



Red Corpuscles of Human Blood. *a*, Seen on the Surface. *c*, Seen in Profile. *b*, Seen in a Roll Magnified 400 Diameters.

What is its appearance under the microscope? How does it conduct itself after standing a while in an open vessel? Describe the Red Corpuscles. Describe the White Corpuscles.

in health, as the red corpuscles. But in certain diseases, and especially if there be a wound in any part of the body to be healed, the white corpuscles are developed at a great rate, although their abundance ceases when the system is restored to a sound state again. Their average diameter is nearly $\frac{1}{30000}$ th of an inch, and they appear to be nucleated cells. The proportion of the white to the red corpuscles in health is nearly as 1 to 346. The whole amount of blood corpuscles has been estimated as high as 65,570,000,000,000.

384. Effect of an Alternate Exposure to Oxygen and Carbonic Acid.—If the red corpuscles are alternately exposed to oxygen and carbonic acid they lose their circular form, and become corrugated or star-shaped, and finally are destroyed; and it is calculated that millions of these corpuscles are destroyed at each pulsation of the heart.

FUNCTIONS OF THE CIRCULATORY SYSTEM.

385. The Main Use of the Blood-Vessels—The large Angle made by the Arterial Branches near the Heart.—The first and most obvious use of the blood-vessels is to allow a free and rapid passage of this fluid to every part of the body. This is evident from the smooth lining of all the arteries and veins, and from the fact that, with the exception of the large arteries near the heart, the vessels branch off at a small angle from each other, which arrangement offers the least possible obstruction to the passage of the blood. In the organs near the heart, as the head and lungs, the blood would readily pass by smaller vessels and by less force of the heart in sufficient quantity. But in that case the parts of the body quite distant from the center of circulation of the blood would

When are the white ones the most abundant? State the approximate number of blood corpuscles in one individual. 384. What effect has an alternate exposure of oxygen and carbonic acid upon these? How many are possibly destroyed at each pulsation of the heart? 385. Give the use of the arteries and veins.

be imperfectly supplied. And apoplexies and congestions would be much more frequent than they now are in the vital organs, if the arteries did not branch off at nearly a right angle.

386. Why a large Amount of Arteries and Veins.—The necessity for such a large amount of arteries and veins, and their numerous connections with each other, is evident from the great variety and extent of the tissues, and also from the great liability to obstruction from inflammations, accidents, or even the ordinary compression of clothing. But arranged as these vessels are in the body, it is a very difficult thing by any mechanical means entirely to check the flow of blood to any part. But were it not for this system of ample inosculation the amputation of a portion of the body would generally produce fatal results.

387. Comparative Capacity of the Arteries and Veins.—If all the arteries in the body were to be made into a single vessel, the capacity of it would be much less than that of a similar vessel made by the union of all the veins. This difference in capacity will in part result from the feebler character of the forces which propel the blood through the veins than through the arteries, and consequently venous obstruction could not be so easily overcome as if it were in the arteries; and in order to compensate for deficiency in power, an increased amount of tubing is provided.

388. Forces of the Arterial Circulation.—The inquiry naturally arises, What are the forces that send the blood through the circulatory channels?

389. Contraction of the Heart—Elasticity of the Middle Coat.—In the first place the contraction of the heart is the most essential force in driving the blood outwards. This force has been estimated at thirteen pounds, though the re-

Why do the arteries near the heart branch off at a large angle? 386. Why is there so large an amount of arteries and veins? 387. What is the comparative capacity of the veins and the arteries? 388. What are the forces of the circulation? 389. What is said of the contraction of the heart? What is the estimate of the force that it exerts?

sult can not be relied on for perfect accuracy; and that this is no inconsiderable force may be inferred from the great amount of resistance that is offered to this current from the ramifications of the smaller arteries, whereby the velocity is increased as well as the surface of resistance. It may also be seen by wounding an artery of medium size, when the blood is sent out in jets, and sometimes to the distance of several feet. This, however, is not the whole amount of the propulsive force in the arterial system, for the middle or elastic coat assists by a secondary action. When the ventricle contracts, or the heart beats, the blood is driven into the aorta and its larger branches with so much force, that the middle coat yields considerably, and the artery is distended beyond its ordinary size. As soon as the contraction of the ventricle ceases, of course the blood is forced back towards the heart by the elasticity of the artery. But as soon as it commences to flow towards the heart the semi-lunar valves close at once, preventing the flow in that direction, so that the whole force of the artery is expended in driving the blood towards the extremities.

390. Pressure of the Muscles.—Another power which aids in the propulsion of the arterial blood is the pressure of the muscles upon the arteries. This is effected by the enlargement which always takes place in the belly of the muscle whenever it is used. This is not a constant power, acting only during exercise of the muscles.

391. Forces of the Venous Circulation.—The agencies by which the blood is returned to the heart are not so well known as those just considered. The valves in the lining membrane of the veins seem to be a contrivance to supply the deficiency of power to drive the blood back.

392. Pressure of the Muscles.—The pressure of the muscles, without doubt, is another important impulse in

When can the forces of the circulation in arteries be well seen? How does the middle coat assist in this work? Of what use are the semi-lunar valves? 390. How does the pressure of the muscles aid in the circulation? 391. How do the valves aid in the venous circulation? 392. Does muscular pressure aid in this?

aiding the return of blood towards the heart. For, as in the aorta, its elasticity forces the blood, first against the semi-lunar valves and then onwards through the arteries, so the muscles, pressing upon the veins, urge the blood into the pouches or valves on their inner coat, which, preventing regurgitation, assist in returning it towards the heart.

393. *Respiration.*—Respiration is another cause that greatly aids in emptying the veins. In some persons a distinct fullness or pulsation of one of the veins of the neck is noticed during each inspiration. This is produced by the partial vacuum made by the act of inhaling air; that is, as a pressure is produced on all parts of the body by the atmosphere, not only a rush of air is made into the mouth, but the blood is forced into the heart by the same cause. And could we examine all the large veins of the body during inspiration, without doubt we should see the blood returning rapidly in them at each inhalation of air.

394. *Affinity of Venous Blood for Oxygen.*—The affinity or desire of venous blood for the oxygen, and the arterial for the tissues, are important causes in the circulation, and especially in the capillaries. It is a principle well known in physics, that if two fluids of different degrees of affinity for a third fluid meet each other in a capillary tube, the fluid having the strongest affinity for the third substance will either partially or wholly force out the other fluid. This takes place equally well through porous substances, membranes, or capillary tubes.

395. So that when pure air is present upon one side of the membrane of the lungs and venous blood on the other, the latter urges itself onward to meet the oxygen, and thus forces that which is already purified into the pulmonary vessels, and thence into the heart.

396. The same thing is seen in the capillaries of the ex-

393. How does the respiratory act aid the circulation of the blood? 394. How does chemical affinity aid in the circulation?

tremities, where the arterial blood, by its affinity for the healthy tissues, forces along that which is already surcharged with carbonic acid into the systemic veins.

397. Forces of the whole Circulation.—The forces, then, which propel the blood through the whole system may be thus briefly summed up :

1. Contraction of the heart.
2. Elasticity of the arteries.
3. Capillary force.
4. Muscular pressure.
5. Act of inspiration.
6. Arterialization of the blood.

398. Course of the Blood through the Body.—As already mentioned, the ventricles are the propelling and the auricles the receiving cavities. Hence, in tracing the course of the blood through the body, beginning with the left ventricle, we find the current passing through the aorta and arteries to all parts of the body except the lungs. As soon as it has gone through the capillaries it returns to the right auricle by the different veins, from which cavity it passes to the right ventricle, and thence to the lungs. After it has received its due supply of oxygen, it is received by the left auricle, from which it passes again to the whole system. The parts of this circle and their order are as follows : left ventricle, arteries, capillaries, veins, right auricle, right ventricle, lungs, and left auricle. Thus we see that the whole circulation in man and all mammalia follows through the body a course represented by the figure 8.

399. Relative Time Occupied by Contraction of Auricles and Ventricles.—The diastole or dilatation of auricles and ventricles occupies a longer period of time than the corresponding systole, or contraction. If we divide the whole

397. Give a synopsis of the circulatory forces. 398. Give the course taken by the blood as it circulates through the body. By what figure may it be represented? 399. What is the systole and diastole of the heart?

portion of time occupied by one pulsation into eight intervals, we shall find that the auricles employ only one of these intervals in contraction, and the remaining seven by dilatation; while the time occupied by the contraction of the ventricles is the same as their dilatation, as may be seen in the diagram.

400. The Sounds of the Heart—Cause of the First and Second Sound.—If the ear be applied over the heart of a healthy person, two sounds will be heard, one of which corresponds in time with the pulsation noticed

at the wrist, or any other large artery of the body. These sounds do not corre-

spond to each other in intensity or duration, but are somewhat indefinitely represented by the sounds given to the monosyllables "lub" and "dup;" the first a long and heavy sound, and the second a short and light one. The first sound is undoubtedly caused by the contraction of the heart, the rush of blood, and the impulse of the organ against the side of the chest; while the second is the clicking of the semi-lunar valves as they close at the commencement of the aorta after the ventricular contraction. That the last sound is due to this cause is proved by an experiment performed on a dog, of introducing a hook through the aorta, and holding back one of these valves, when the second sound entirely failed.

401. Number of Pulsations per Minute.—The number of pulsations of the heart varies considerably at different periods of life. Thus the following table shows the average number of pulsations each minute at different ages :

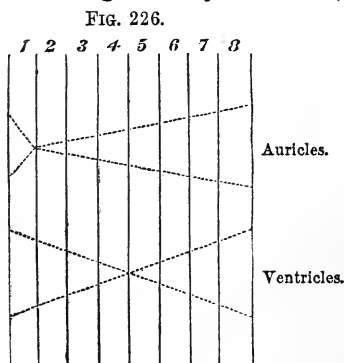


Diagram showing the relative Time occupied by the Contraction of the Auricles and Ventricles, the converging lines from left to right indicating the contraction, and the diverging ones the dilatation.

Give the relative time occupied by the contraction and dilatation of the auricles and ventricles. 400. What two sounds are made at each complete pulsation of the heart? Give the causes of the first sound. What is the last sound owing to? What proof of it?

New-born infant.....	130	to	140
During the 1st year.....	115	"	130
" " 2d " 	100	"	115
From the 7th to the 14th year	80	"	90
" 14th " 21st " 	75	"	85
" 21st " 60th " 	70	"	75
Old age.....	75	"	80

402. Causes affecting the Pulsations.—Muscular exertion has a considerable influence upon the rapidity of the contraction of the heart. So also has the position of the body, whether sitting, lying, or standing. The time of day or night likewise has an important influence, the highest number of pulsations being found at noon, and the fewest at midnight.

403. Use of the Corpuscles.—The function of the Red Corpuscles seems to be to convey oxygen to the tissues, and as this is the agent which is continually promoting the change or waste of the system, these corpuscles seem to be the great agents for disassimilating the tissues and the blood itself. The colorless or white corpuscles seem to be the agents by which the repair of the body is effected, since they are greatly augmented in number when there is a large wound to be healed, or when there is a great amount of internal or external inflammation.

403a. Statistics.—In an ordinary life of a man the heart beats at least 3,000,000,000 times, and propels through the aorta one half a million tons of blood.

HYGIENIC INFERENCES.

404. But few Diseases of the Circulatory Organs.—
1. Though the blood-vessels are so constantly in use, and so easily excited by every muscular movement and mental emotion, yet they are affected by only a few diseases, and many

401. State the number of pulsations of the heart at different periods of life. 402. What causes modify the number of the pulsations? 403. What is the probable business of the Red Corpuscles? What of the White? 404. Are there many diseases of the Circulatory organs?

of these affections, which seem to be diseases of the heart, are merely sympathetic, and the difficulty lies in other organs.

405. Avoidance of sudden Efforts.—2. But those persons who have a tendency to diseases of the heart, sympathetic or organic, should be on their guard against sudden exertions, and, to as great an extent as possible, avoid mental anxiety and alarms. Heart diseases are most common late in life, at or about sixty years of age.

406. Principal Danger from Wounds.—Treatment of Wounds of Arteries.—3. The principal danger to be feared from these organs results from wounds. If these are in the arteries, they require prompt attention, but if in the veins, they need scarcely ever excite fear. If an artery be wounded—which can always be known by the escape of blood in jets, and not a steady stream—the wound should be either closed, or the artery pressed upon between the wound and the heart with so much force as to stop the flow of blood through it. In case of any such arterial wound it will always be well to tie a bandage as tight as possible immediately over the wound, and then compress the artery as already mentioned. If the wound be on the hand or forearm, the brachial artery may be found and compressed just above the inner angle of the elbow. Or if it is desirable to compress the artery still higher up, the axillary artery may be found in the armpit, where by pressing outwards, nearly all the blood flowing to the arm may be checked.

407. Method of Checking the Blood to the Lower Extremities.—4. If it is desired to check the flow of blood to the lower extremity, the popliteal artery lies directly against the femur upon the backside of the knee-joint, where a compression of it may be effected with great advantage. Nearer the heart (in the groin) the femoral artery is found, where it

405. What should those persons predisposed to these diseases especially be on their guard against? At what time of life are Heart diseases the most frequent? 406. How can we distinguish between the wound of a vein and that of an artery? How may arterial hemorrhage be most readily checked in the upper extremities? 407. How may it be checked in the lower extremities?

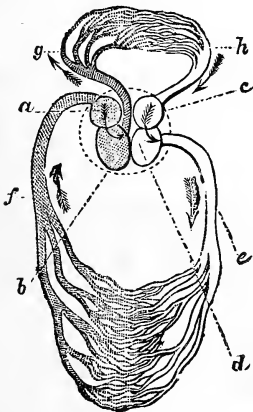
crosses the os innominatum lying just beneath the skin. Here an efficient compression may be made, since all the anterior part of the thigh and the whole of the leg proper, is supplied with blood from this artery.

408. 5. Except bad wounds, however, a tightly drawn bandage, directly over the wound, thoroughly wet with cold water, will check hemorrhage sufficiently, until a surgeon can be called.

COMPARATIVE ANGIOLOGY.

409. Heart of Mammals.—In all mammals the heart is

FIG. 227.



Circulation in Man. *a.* Right Auricle. *b.* Right Ventricle. *c.* Left Auricle. *d.* Left Ventricle. *e.* Aorta. *f.* Vena Cava. *g.* Pulmonary Artery. *h.* Pulmonary Veins.

divided into four cavities, as in man. Its form, however, is more rounded and less elongated. In one species of the whale this organ is cleft in a peculiar manner, the division between the two ventricles being indicated externally by a deep fissure in its apex. In the Ox, Hog, Sheep, and Goat there are always found one or two bones in the divisions between the ventricles. In most mammals it is placed more in a right line with the middle of the body, and not so obliquely as in man.

408. What treatment will check all ordinary hemorrhages? 409. What is peculiar in the heart of the Whale, the Ox, the Sheep, and Goat? Where is the heart located in quadrupeds?

410. Aorta and Pulmonary Veins.—The manner in which the Aorta and its branches are given off varies greatly in these animals, as may be seen by the cut. The number of Pulmo-

FIG. 228.

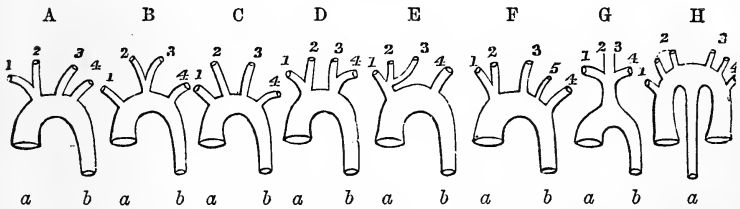
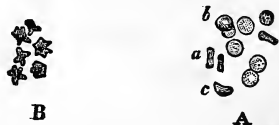


Diagram of the Principal Varieties of the Aorta in its Principal Branches in A, Man ; B, Elephant c, Cetacea ; D, Bat ; E, Carnivora ; F, Seal ; G, Ruminants ; H, Reptiles. 1, Right Subclavian. 2, Right Carotid. 3, Left Carotid. 4, Left Subclavian. 5, Vertebral. a, Ascending and b Descending Aorta.

nary Veins varies upon the different sides of the body, and is generally according to the number of lobes in the lungs, the relations of the sides being represented by the formula $3 + 2$.

411. Economy of Diving Animals.—In diving animals the vena cava is capable of great dilatation, in order to contain an unusual quantity of blood which accumulates there when the animal suspends respiration under water, since it can not be purified except in the lungs. Still further protection to the heart in diving animals is seen in the vena cava ascendens, where a circular muscle, by its contraction, can completely cut off the flow of blood to the heart from the lower extremities.

FIG. 229.



Red Corpuscles of the Ox. A, In their Natural State. a, Seen in Profile. b, Seen on the Surface. B, Altered Corpuscles.

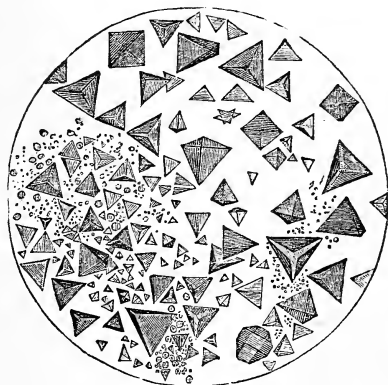
412. Blood Corpuscles of Mammals—Wonder Nets.—

The blood of mammals, for the most part, presents small round, disc-shaped corpuscles, similar to, but smaller than those in man. This is especially

410. What is peculiar about the aorta and pulmonary veins in many mammals? 411. What is the arrangement of the vena in diving animals?

true of ruminants. The largest animals, such as the elephant, have very small corpuscles. In some of the camels and llamas the corpuscles are large and somewhat elongated. The same

FIG. 230.



Blood Crystals of the Guinea Pig.

is true of the dromedary. Crystalline substances are found in the blood of other mammals as well as man. The annexed cut shows crystals from the blood of the Guinea pig.

The distribution of the arteries of quadrupeds is a subject of considerable interest. In grazing animals, which hold their heads low, in

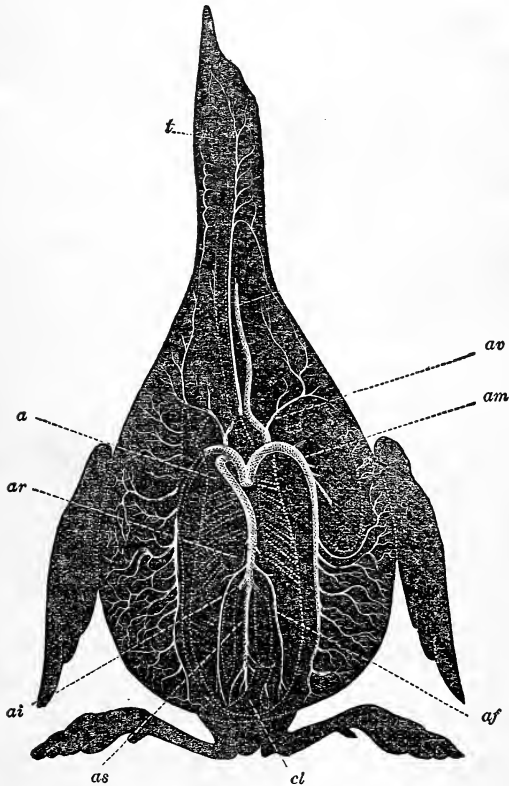
addition to large arterial trunks, we find a great number of very small ones, which are exceedingly tortuous in their course, called "Wonder Nets." This arrangement is to prevent a too rapid flow of blood to the head by the force of gravity, which would of necessity take place when the head is so constantly in a dependent position. A similar disposition is seen in the limbs of the sloth and other animals which are like them in tardiness of movement. In the fore-leg of the lion, where great muscular force is exerted, the main artery passes through a perforation in the bone, so as to secure it from obstruction to the flow of blood by pressure of the rigid muscles.

413. Heart of Birds.—The heart of birds is highly muscular and of very large size in proportion to the bulk of the body, and in general structure resembles the same organ in mammals. The valves of the right ventricles, however, are supplied with a strong band of muscular fibers, which gives

412. What is peculiar about the blood discs or corpuscles of the larger animals? What is the form of nearly all of them? In what animals are they oval? What are Wonder Nets, and why are they introduced? 413. What is worthy of note with reference to the heart of birds?

additional impulse to the blood as it is forced into the pulmonary arteries. The need of this arrangement is to give a full supply of blood to the lungs, which the ordinary powers of the heart could not effect.

FIG. 231.



Arterial System of a Bird.

Arteries of the Grèbe. *a*, Aorta. *am*, One of its large Branches. It gives off the Carotid (*ac*) and Subclavian, is ultimately distributed to the muscles of the chest, and corresponds to the mammary arteries of mammals. *av*, One of the Branches of the Vertebral Artery supplying the Muscles of the Shoulder. *ce*, Arterial Loops formed by the Branches of the External Carotid. *al*, Lingual Artery. *i*, Trachea, or wind-pipe. *ar*, Renal Arteries. *ai*, Ischiatic Artery proceeding to the lower extremities. *as*, Sacral Artery, forming a continuation of the Aorta, and giving origin to the Inferior Mesenteric Artery, etc. *cl*, The Cloaca.

Why do the valves have an especial muscle?

414. Arteries—Wonder Nets.—The trunk of the aorta is very short, and after giving arteries to supply the heart it divides at once into two large branches, quite unlike the conformation in mammalia. Wonder nets, too, are often found in birds, and especially in those arteries supplying the brain, eyes and legs.

FIG. 232.

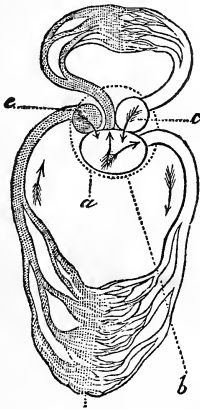


Pigeon's Blood (red) Corpuscles Magnified 400 Diameters. A, In Natural State. B, Altered by Acetic Acid.

415. Blood.—The blood of birds has the highest temperature of the vertebrate animals—110° F. The blood cells, or corpuscles, are always of an elliptical form and of a very uniform diameter.

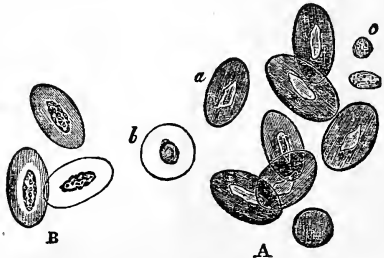
The heart of reptiles ordinarily consists of a single ventricle,

FIG. 233.



Circulation in Reptiles. a, Heart. b, Ventricle. c, c, Auricles.

FIG. 234.



Blood Corpuscles of the Frog, 400 Diameters. A, In Serum. a, Fully Developed. b, Nucleus with clear contents.

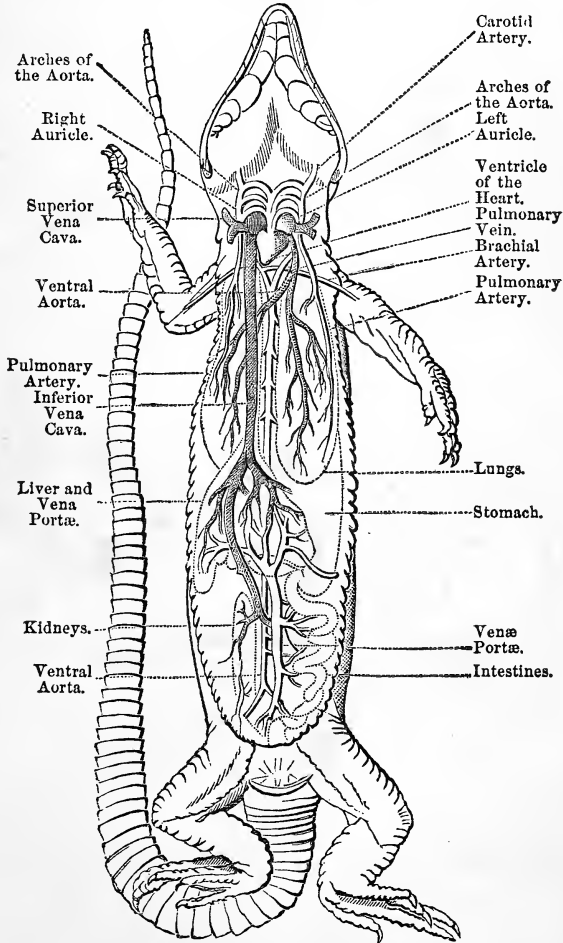
or propelling cavity, and two auricles, or receiving cavities, so that the pure blood is mixed with the impure (or a portion of it) as it

comes from the lungs, which accounts in part for the general sluggishness of these animals. The blood corpuscles of reptiles are large and oval, as may be seen in Fig. 234.

414. Into how many branches does the aorta at once divide? Where are wonder nets found in birds? 415. What is said of the temperature of birds? What of blood-cells? 416. Describe the heart of reptiles. What is the effect upon the blood? What is the size of their blood-vessels?

417. Blood-Vessels.—The arrangement of Blood-Vessels is very diverse, since one portion of them breathe by gills and another by lungs, while frogs in their early condition are fur-

FIG. 235.

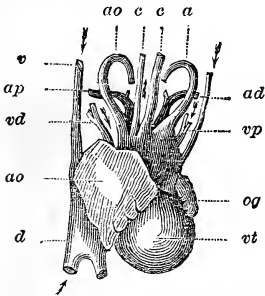


Circulatory Apparatus in the Lizard.

417. Why are blood-vessels arranged differently in many of the reptiles?

nished with the former, but in adult age, after passing through a metamorphosis, have the latter system of respiratory vessels.

FIG. 236.



Heart of Crocodile. *v*, Veins. *ao*, Right Auricle. *vt*, Ventricles. *ap*, Pulmonary Arteries. *a*, A Vessel proceeding from the Ventricle to the Aorta. *og*, Left Auricle.

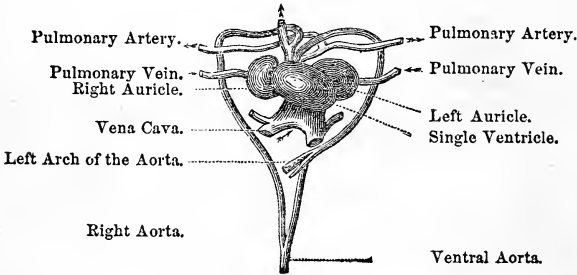
418. Heart of Crocodile.—Crocodiles and turtles exhibit the most perfect form of heart, for it agrees essentially with that of mammals, as may be seen in Figs. 236 and 237. But there is a small opening just at the outlet of the two ventricles, so that the pure and impure blood is mixed.

supplying the kidneys and another the liver.

419. Portal System.—Reptiles have a double Portal System, one set of vessels

420. Lymphatic Hearts.—Many reptiles have small sac-like organs lying just beneath the skin in certain portions of the body, which, from their containing lymph and showing

FIG. 237.



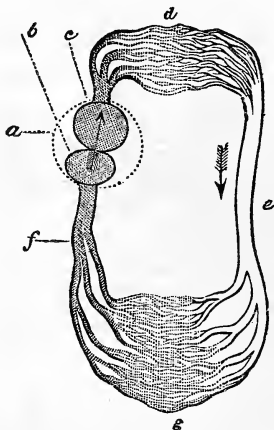
Heart of the Turtle.

pulsations, are called Lymphatic Hearts. In the Frog, two such hearts are situated on the back of the animal, between the joints of the thigh bones.

418. What animals of this class have the most perfect form of a heart? 419. What kind of a portal system do we find among reptiles? 420. Describe lymphatic hearts.

421. Heart of Fishes.—The heart consists of one auricle and one ventricle, which are covered by a pericardium, and the whole organ is very small in proportion to the size of the whole body, being from $\frac{1}{400}$ th to $\frac{1}{1000}$ th its weight. In the osseous fishes the heart is elongated and conical, while in the Sharks and Rays it is broader. The ventricle discharges its blood through the aortic trunk upon the gills. This trunk divides up into a large number of minute branches which ramify upon the gills, and after the blood has received its oxygen from the water. it is collected by a corresponding set of vessels, and emptied into another trunk which supplies all the rest of the body—which trunk corresponds to the aorta—though it has no muscular power to propel the blood along. After it has performed its office it is collected by a system of vessels similar to veins, and returned to the auricle.

FIG. 238.



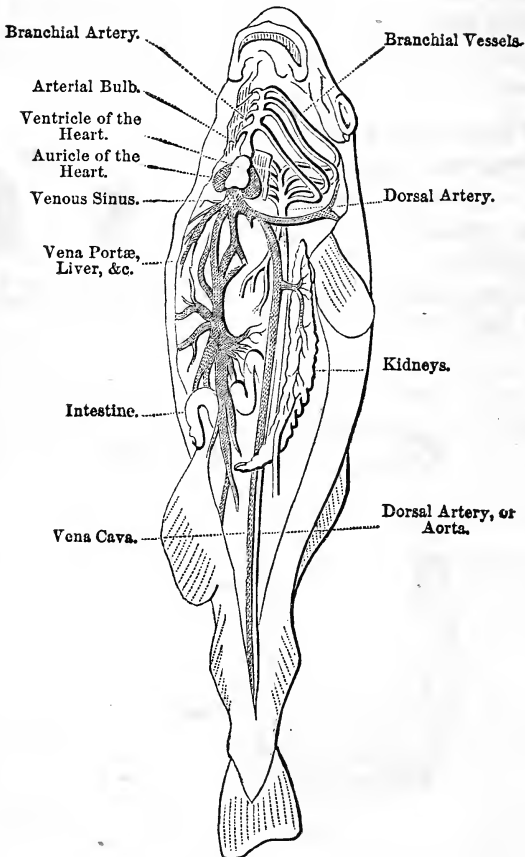
Circulation in Fishes. *a*, Heart. *b*, Auricle. *c*, Ventricle. *d*, Circulation through the Gills, or Lesser Circulation. *g*, Circulation through the Body, or Greater Circulation. *e*, Arteries. *f*, Veins.

422. Pulsations in a Minute.—Commonly not more than twenty or thirty beats in a minute may be counted in fishes, while in birds one hundred may be counted in the same time.

423. Portal Circulation.—In fishes, as in reptiles, there seems to be a double portal circulation.

421. Why is the heart of the osseous fishes called a branchial heart? What proportion of the body does it constitute? Give the course of circulation. 422. What number of pulsations can be counted in the heart of fishes, and what number in birds?

FIG. 239.



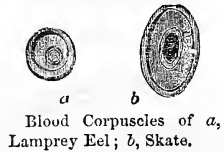
Circulating Apparatus of the Fish.

424. **Accessory Hearts—Caudal Heart.**—Among many fishes are found what are termed Accessory Hearts, or small muscular organs which seem to aid in the propulsion of blood through the different parts of the body. Thus, in the myxine, the portal vein is distended into a large sac, which expands and contracts alternately; and in eels there is found upon

both sides of the last caudal vertebra a pulsating organ which receives the blood from the delicate veins of the caudal fin, and propels it into the caudal vein, this constituting a true caudal heart.

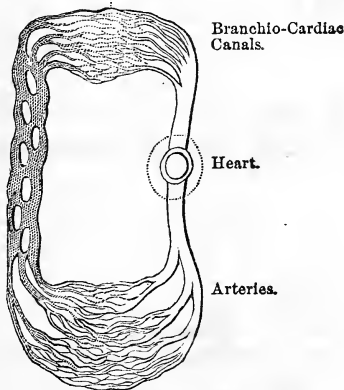
425. Fishes' Blood.—The blood of fishes, almost without exception, is of a red color, and contains oval and slightly bi-convex corpuscles. In one family they are distinguished by their great size, and thus resemble those of frogs; but other families have smaller ones.

FIG. 240.



Blood Corpuscles of *a*, Lamprey Eel; *b*, Skate.

FIG. 241.
Smaller Circulation.

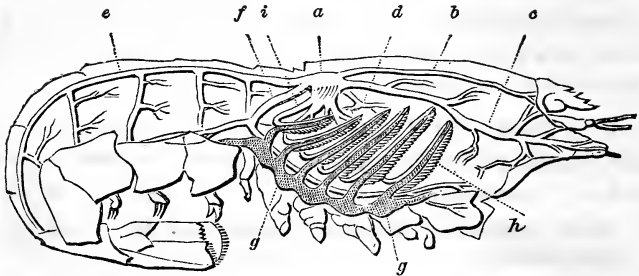


Greater Circulation.
Diagram of the Circulation in Fishes.

426. Dorsal Vessel, or Heart of Articulata.—In articulata, a vessel or tube passes along the back of the body—behind the intestines and in front of the chain of ganglia—called the Dorsal Vessel, which is divided into as many portions as there are segments of the body. This is really the

What peculiarity in the tail of the eel? 425. What is the color of fishes' blood, and what are its corpuscles? 426. What is the Dorsal Vessel of articulata?

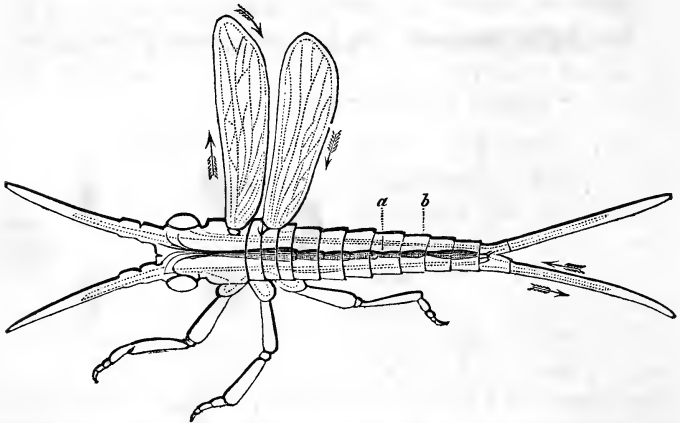
FIG. 242.



Circulatory Apparatus in the Lobster. *a*, The Heart. *b*, Ophthalmic Artery. *c*, Antennar Artery. *d*, Hepatic Artery. *e*, Abdominal Artery. *f*, Sternal Artery. *g*, Venous Sinuses. *h*, Branchiæ.

heart of the animal, since by the contraction of its coats the blood or contained fluid is forced along. Small arteries are given off from this dorsal vessel all along its course. This

FIG. 243.



Circulation in Insects. *a*, Dorsal Vessel. *b*, Principal Lateral Currents. The Arrows show the direction of the Fluid.

plan, however, is seldom completely carried out, but is most fully exemplified in the class of insects which is partly exhibited in Fig. 243.

427. **Ventral Trunk.**—The blood which is driven forwards by this dorsal vessel is collected by a set of vessels which unite into a large tube called the Ventral vessel, or trunk, which returns it to the posterior part of the body.

428. **Blood of Articulates.**—This fluid called blood is a thin liquid, yellowish brown, red, green, or even colorless, and never containing corpuscles; and the only reason why it is called blood is, that it circulates like the blood of the higher animals.

429. **Chylaqueous Fluid.**—But besides this fluid there is another found in the general or abdominal cavity of the body, which, though not contained in organs expressly designed for its circulation, yet is rapidly carried through the body by means of the motion of the different segments of the animal, which in many of this order is incessant. This fluid, unlike the true blood, is rich in corpuscles and easily coagulated, which gives it one of the essential characteristics of true blood in the higher animals. It, however, must probably be regarded as the chylaqueous fluid of many of the lower vertebrata. Scorpions have arteries and veins.

430. **Heart and Blood of Crustacea.**—Among the crustaceans, such as the crab and lobster, we find a vessel much shorter than the dorsal vessel of most articulata, which resembles a heart from the fact that it is a propelling organ and has muscular fibers in its coats. The blood in these animals is of a whitish or purple color, and the pulsations of the heart vary in number from fifty-one to two hundred per minute.

FIG. 244.

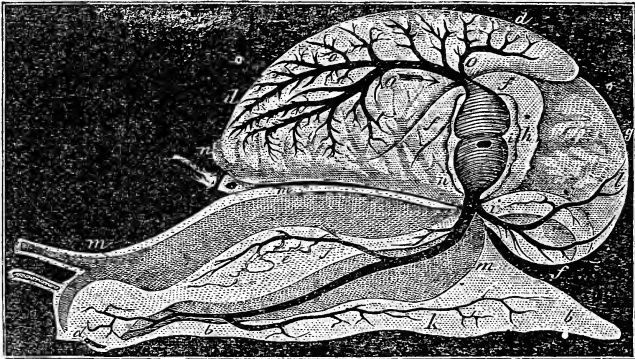


Blood Corpuscles of the Crab. A, Granule Cells. B, Nucleated Cells.

427. How is the blood returned that is circulated by the dorsal heart? 428. Describe the blood of articulates. 429. What other fluid is found in these animals? 430. What is said of the heart and blood of the crab and lobster?

431. **Circulation in Molluscs.**—The higher orders of molluscs show a system of circulating vessels which seem to be arteries and veins, with a central vessel answering to a heart. There is usually a ventricle corresponding to the right ventricle in man, to send the blood to the respiratory organ. There is also another cavity which corresponds some-

FIG. 245.



Anatomy of the Snail. *a*, Mouth. *b*, Foot. *d*, Lung. *e*, Stomach. *f*, Intestine. *g*, Liver. *h*, Heart. *i*, Aorta. *j*, Gastric Artery. *l*, Hepatic Artery. *k*, Artery of the Foot. *m*, Abdominal Cavity. *n*, Canal conveying the Blood to the Lungs. *o*, Vessel carrying Blood from Lung to Heart.

what to an auricle, which receives the blood as it enters the heart. But with the exception of the vessels carrying blood to the gills, there are few separate tubes for carrying this fluid through the body, it being left to circulate by imbibition, or it is effected by means of the lacunar spaces, Fig. 245.

432. **Blood of Molluscs.**—The blood of these animals is generally destitute of corpuscles, and is sometimes colorless, though often white, brown, red, or green.

433. **Contractions of the Heart.**—The heart does not

431. What are the circulatory vessels in molluscs? How is most of the fluid circulated? 432. What of the blood of molluscs?

expand and contract regularly, but in a spiral, screw-like manner, like the peristaltic motion of the intestines.

434. Circulation in the Radiata and Protozoa.—In a few polyps a vascular system is quite obvious, and may be inferred in them all. The blood is colorless, and has white corpuscles. In the Acalephæ there exists a circulating fluid, which is thought by Agassiz and Dana to be merely water, intended to subserve the purposes of respiration rather than nutrition. The Echinoderms have one heart, and sometimes more. The Infusoria have pulsatory cavities, but no system of circulation.

433. How does the heart pulsate? 434. What is the plan of circulation among the radiate animals?

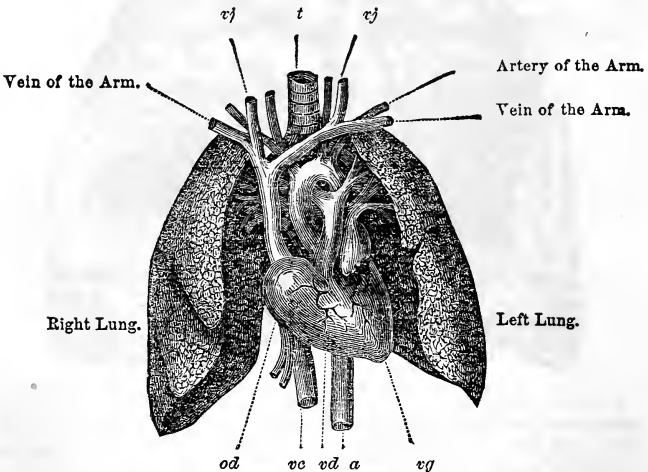
CHAPTER FIFTH.

PNEUMONOLOGY, OR HISTORY OF THE ORGANS OF BREATHING. —THE RESPIRATORY, VOCAL, AND CALORIFIC ORGANS.

DEFINITIONS AND DESCRIPTIONS.

435. Location of Respiratory Organs.—Sympathy between the Heart and Lungs.—Within the thorax are contained not only the central organs of circulation, but other organs closely related, and connected with them, the Respira-

FIG. 246.



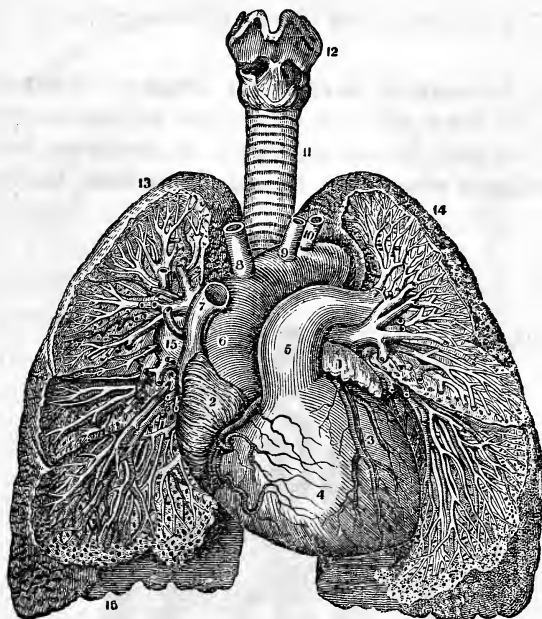
Lungs, Heart, and Principal Vessels in Man. *od.* Right Auricle. *vd.* Right Ventricle. *vg.* Left Ventricle. *a.* Aorta. *ac.* Carotid Arteries. *vc.* Vena Cava. *t.* Trachea. *vj,* Jugular Veins.

435. What organs are contained in the thorax? What is said of the sympathy between the respiratory and circulatory organs?

tory. These are not only related by position, but are mutually dependent on each other for their action. Thus, if severe disease affect the heart, the lungs are very apt by imperfectly or irregularly performing their offices, to show their sympathy. In like manner, if the lungs exhibit disease, sooner or later the heart is sure to manifest its sympathy with its suffering neighbors.

436. The Lungs, their Shape, their Color, Lobes of the Right Lung, Capacity of the Right Lung, Amount of

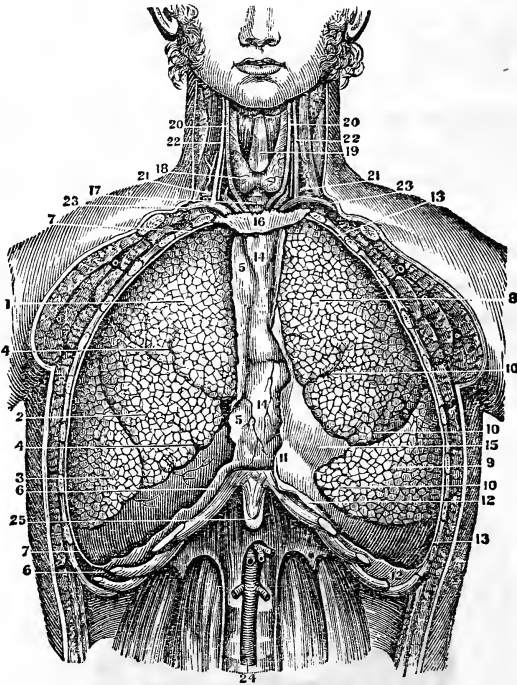
FIG. 247.



A View of the Bronchia and Blood-Vessels of the Lungs as shown by Dissection, as well as the relative Position of the Lungs to the Heart. 1, End of the Left Auricle of the Heart. 2, The Right Auricle. 3, The Left Ventricle with its Vessels. 4, The Right Ventricle with its Vessels. 5, The Pulmonary Artery. 6, Arch of the Aorta. 7, Superior Vena Cava. 8, Arteria Innominata. 9, Left Primitive Carotid Artery. 10, Left Sub-Clavian Artery. 11, The Trachea. 12, The Larynx. 13, Upper Lobe of the Right Lung. 14, Upper Lobe of the Left Lung. 15, Trunk of the Right Pulmonary Artery. 16, Lower Lobes of the Lungs. The Distribution of the Bronchia and of the Arteries and Veins, as well as some of the Air-Cells of the Lungs, are also shown in this dissection.

Blood in each Lung.—The essential organs of respiration are the Lungs. These are light solids, two in number, and occupy nearly four fifths of the cavity of the chest. They

FIG. 248.

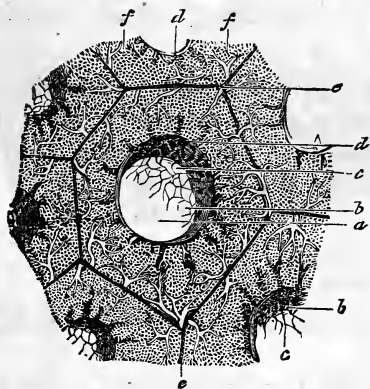


An Anterior View of the Thoracic Viscera in Situ, as shown by the Removal of their Anterior Parietes. 1, Superior Lobe of the Right Lung. 2, Its Middle Lobe. 3, Its Inferior Lobe. 4, 4, Lobular Fissures. 5, 5, Internal Layer of the Costal Pleura forming the Right Side of the Anterior Mediastinum. 6, 6, The Right Diaphragmatic Portion of the Pleura Costalis. 7, 7, The Right Pleura Costalis on the Ribs. 8, Superior Lobe on the Left Lung. 9, Its Inferior Lobe. 10, 10, Interlobular Fissures. 11, The Portion of the Pleura Costalis which forms the Left Side of the Anterior Mediastinum. 12, The Left Diaphragmatic Portion of the Pleura Costalis. 13, Left Pleura Costalis. 14, 14, The Middle Space between the Pleuræ, known as the Anterior Mediastinum. 15, The Pericardium. 16, Fibrous Partition over which the Pleuræ are reflected. 17 The Trachea. 18, Thyroid Gland. 19, Anterior Portion of the Thyroid Cartilage. 20, Primitive Carotid Artery. 21, Subclavian Vein. 22, Internal Jugular Vein. 23, Brachio-Cephalic Vein. 24, Abdominal Aorta. 25, Xiphoid Cartilage.

are of a conical shape, the apex pointing upwards, the base resting on the Diaphragm, of a pinkish gray color, frequently dotted with black spots, and divided by a deep fissure into two lobes. The right lung is shorter in its long diameter than the left, on account of the liver which raises the right side of the diaphragm higher than the left. The right lung is subdivided again, so that it is really made up of three lobes instead of two. It has also a larger capacity than the left, since the position of the heart, considerably upon the left side of the median line of the body, occupies a portion of the left thorax. Each of the lungs ordinarily contains a pint of blood.

437. *Lobules of the Lungs.*—A closer examination of the lungs shows them to be made up of small bodies called Lunglets. These are from $\frac{1}{8}$ th to $\frac{1}{2}$ th of an inch in diameter, and of a conical or pyramidal shape. They are much more clearly defined in small children than in adults. Fig. 249, by the

FIG. 249.



A Lunglet with a Section of a Bronchial Tube. *a*, Bronchus. *b* and *c*, Vessels of Bronchial Lining Membrane. *d, d, e, e*, Spaces between contiguous Lobules, containing the Terminal Pulmonary Arteries and Veins supplying the Capillary Plexus (*f, f*) to the Meshes of which the air gains access by the Lobular Passages.

Give their shape, color and division. What are the lobes of the lungs? Which is the largest lung, and why the difference? 437. How are the lungs made up? At what period of life can the lunglets be best seen?

hexagonal figure surrounding the bronchial tube, shows a section of a lunglet, or lobule of the lung.

438. *The Pleura.—Pleurisy.—Root of the Lungs.*—The lungs are immediately invested with a serous membrane called the Pleura, which is also the inner lining membrane of the walls of the chest: so that when the lungs are fully inflated, these two surfaces are brought in contact, and in the act of respiration move slightly upon each other. And if any portion of these membranes becomes inflamed, the disease results which is known as Pleurisy. In the acute or early stage of this disease, if a long breath be drawn, intense pain is felt at the lower portion of the lung. This is owing to the friction of these inflamed membranes one upon the other, and the reason why the pain is severest in the lower part of the lung, is that this part of the lung moves over the largest space in breathing. The vessels for supplying blood, emptying it and nourishing the lungs, as well as the air-vessels, nerves and lymphatics, are all collected together in one bundle at the inner side of these organs, and are collectively called the Root of the Lungs.

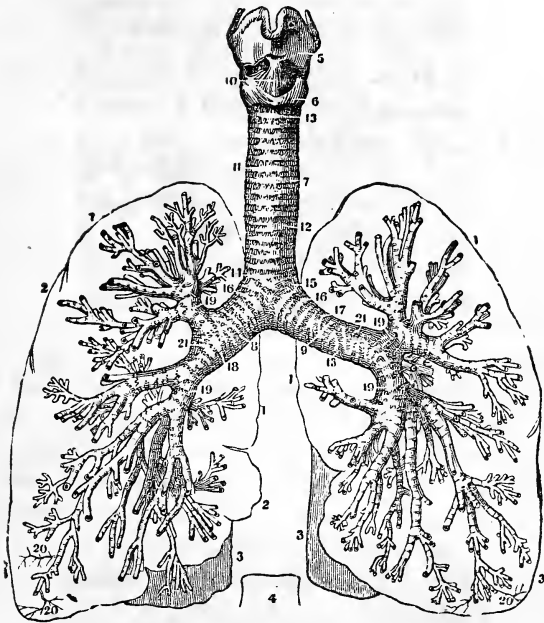
439. *The Air Passages.*—The vessels which are especially designed for the purpose of conveying air into the lungs are the Larynx, from the Greek meaning a whistle, since sound is made in it—the Trachea, meaning rough, as is its structure—the Bronchia, meaning the windpipe, (Fig. 250, p. 249), and the intercellular passages which terminate in the air-cells. (Fig. 252, p. 250.)

440. *The Larynx.*—The Larynx is a conical cartilaginous tube from one to two inches in diameter, opening upwards into the Pharynx, and terminating below in the Trachea. (See *Organs of Voice.*)

441. *The Trachea.*—The Trachea is a cartilaginous tube

438. What are the lungs covered with, and what is the chest lined with? What is Pleurisy? What is meant by the root of the lung? 439. Give the names of the different parts of the air-passages. 440. Describe the Larynx.

FIG. 250.

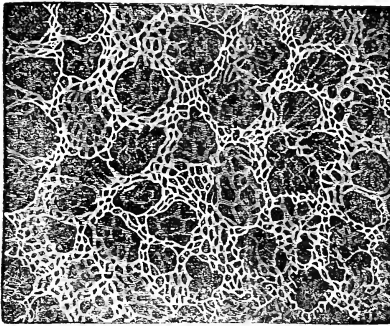


The Larynx, Trachea, and Bronchia, deprived of their Fibrous Covering, and with the outline of the Lungs. 1, 1, Outline of the Upper Lobes of the Lungs. 2, Outline of the the Middle Lobe of the Right Lung. 3, 3, Outline of the Inferior Lobes of both Lungs. 4, Outline of the Ninth Dorsal Vertebra, showing its relation to the Lungs and the Vertebral Column. 5, Thyroid Cartilage. 6, Cricoid Cartilage. 7, Trachea. 8, Right Bronchus. 9, Left Bronchus. 10, Crico-Thyroid Ligament. 11, 12, Rings of the Trachea. 13, First Ring of the Trachea. 14, Last Ring of the Trachea, which is Corset-shaped. 15, 16, A complete Bronchial Cartilaginous Ring. 17, One which is Bifurcated. 18, Double Bifurcated Bronchial Rings. 19, 19, Smaller Bronchial Rings. 20, Depressions for the Course of the large Blood-Vessels.

about one inch in diameter, made up of from fifteen to twenty cartilaginous rings, commencing at a point nearly opposite the fifth cervical vertebra, and extending as low as the second dorsal, or top of the sternum, where it divides into two bronchi extending to each lung. These segments of the trachea are not perfect rings, since they complete only about five sixths

441. How is the trachea made up? Where does it divide into the two bronchi? Are the segments of the trachea perfect rings?

FIG. 251.

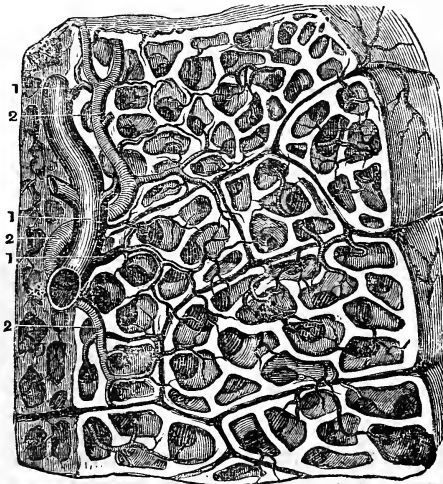


Capillaries of the Human Lung.

of a circle, the remaining sixth consisting of smooth or involuntary muscular fiber.

442. The Bronchi.—Intercellular Passages.—Cæcal Air-Cells. Their Number.—As soon as the Bronchi fairly

FIG. 252.

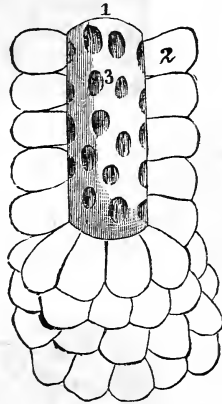


A Magnified View of a Section of the Lung, showing the Arrangement of some of the Lobules, the Communication of the Air-Cells in one Lobule and their Separation from those of the adjoining-Lobule. The Ramifications of the Blood-Vessels in the Texture of the Lung and their Course through the Air-Cells are also seen: 1, 1, Branches of the Pulmonary Veins. 2, 2. Branches of the Pulmonary Artery.

enter the lungs, they immediately divide and subdivide, until they have diminished to a diameter about one fiftieth of an inch, and some of them are within one eighth of an inch of the outside of the lung. After this they are changed in their structure, and become channels hollowed out in the cellular tissue of the lung, and are called Intercellular Passages. These terminate in minute cells, called Cæcal Air-Cells. These cells have an average diameter of $\frac{1}{150}$ th of an inch, and accumulate around each terminal bronchus to the number of 17,790, making a total in the lungs of 600,000,000, which, if spread out, would make an area of cell surface of 132 square feet; Dalton says 1,400 square feet.

443. Composition of the Air-Tubes. Their Mucous and Pleural Surfaces.— These air-tubes just described are essentially composed of cartilage and fibro-cartilage, and lined throughout with mucous membrane. Hence we see that this membrane, though situated nearest the center of the body, lines the *outside* of the lungs, while the Pleura, although nearer the surface of the body, lines

FIG. 253.



Longitudinal Section of the Termination of a Bronchus. 1, Bronchus. 2, Cæcal Air-Cell. 3, Orifice of the same.

FIG. 254.



Small Bronchial Tube laid open.

442. What are the bronchial tubes subdivided into? How large are the cæcal air-cells? How many around each terminal bronchus? What is their aggregate number? What is the area of cell surface in the lungs? 443. What is the composition of the air-tubes? Which is really the inside and which the outside of the lungs?

the *interior* of the lungs. This apparent contradiction of terms arises from considering that portion of the body as external which is in contact with the air, in the same manner as the intestines; the anatomically external surface being physiologically the internal surface.

444. The Substance of the Lungs.—The substance of the lungs is entirely made up of arteries, veins, lymphatics, and bronchial tubes, connected by areolar tissue. And when inflammation takes place in this substance, the disease is known as pneumonia, or lung fever.

445. The Essential Muscle of Respiration—Process of Breathing—The Rest Gained by the Respiratory Muscles.—The muscle which performs the most essential part of breathing is the diaphragm. This by its contraction produces inspiration, but does not directly produce expiration. Breathing is performed as follows. The cavity of the chest is variable in size; made so by the movement of the diaphragm upwards and downwards. For as the sides and upper portion of the chest are unyielding walls, if the diaphragm be depressed the cavity of the chest is enlarged, a partial vacuum is produced, and the air rushes in to supply the vacancy. This is inspiration, and is purely an active muscular effort. Expiration, however, is quite the reverse, being wholly a passive exercise. For when the lungs are filled, the contents of the abdomen are depressed by the descending diaphragm and the ribs are elevated, both of which parts offer resistance to the inhaling force. Consequently, when the diaphragm and the other respiratory muscles are relaxed, several muscles of the back, abdomen, and chest, by their elastic tonicity, force air again out of the mouth, which completes the process of expiration without expending any nervous energy, and at the same time gives rest to the muscles employed in breathing. Hence the muscles of respiration are not all the time in ac-

444. What is the substance of the lung composed of? Define pneumonia. 445. What is the principal muscle of respiration? Describe the mechanism of breathing. Which act is active and which is passive? When do the respiratory muscles rest?

tion, but as the period occupied by expiration is longer than that of inspiration, consequently they rest during a longer time than they are in action.

FUNCTIONS OF THE LUNGS.

446. **The First Object of Breathing.**—The immediate object of breathing is to bring air into the lungs and carry it out again after it has performed its office; and the function of the lungs is to expose as large a surface of blood as possible to the air inhaled. The ultimate objects of this arrangement are to remove waste products from the body, which exist in the form of carbonic acid and water, and also to generate the animal heat necessary. A third, but by no means an inconsiderable value of this function, is to convert the gluten of vegetable food into fibrin.

447. **Another Use of Breathing, Purifying the Blood—Endosmose and Exosmose.**—The impurities of the blood—carbonic acid and water—are exchanged for the oxygen of the atmosphere. This is not effected by actual contact of blood and air, but through an intervening membrane, the wall of the air-cells. It is a remarkable property of membranes, both animal and vegetable, called Imbibition, or Endosmose and Exosmose, that allows fluids and gases to pass through them in opposite directions at the same time. Through the membrane of the lungs, the carbonic acid, which has more affinity with pure air than for the blood, passes outwards, while the pure air, containing oxygen, has an affinity for the blood, and passes inwards.

448. **Amount of Air Used in Breathing—Causes of its Variation—Capacity of the Chest.**—The average amount of air which passes in and out of the lungs at each inspiration

446. What is the object of breathing, and what is the function of the lungs? What three processes are accomplished by this process? 447. How does breathing purify the blood? Describe the process of imbibition.

and expiration is about twenty cubic inches, and the amount passed through them in twenty-four hours about 360 cubic feet, or, as others estimate it, from 3,000 to 5,000 gallons every day. This varies greatly. In the first place, the lower the temperature the greater the amount of animal heat to be generated, and consequently the greater the quantity of air to be consumed. Also a person laboring in the open air breathes more deeply than one confined to the house. Again, the capacity of the lungs modifies the quantity of air inhaled. And this capacity depends more upon the height of the individual than any other physical feature. From a series of 5,000 observations made by Dr. Hutchinson, the following principle is deduced. "For every inch of stature from five to six feet, eight additional cubic inches of air are given out at a forced expiration after a full inspiration." That is, if a person five feet and six inches in height can expire 422 cubic inches, a person five feet and seven inches can expire 430 cubic inches.

449. Effect of Corpulence on Capacity of Lungs.—Another fact of importance is deduced by the same experimenter—that if a person exceed the average weight on account of corpulence, the capacity of the lungs decreases in a marked ratio, as is stated in these words: "When the man exceeds the average weight (at each height) by 7 per cent. the vital capacity decreases one cubic inch per pound for the next thirty-five pounds above that weight."

450. Function of the Red Corpuscles.—The red corpuscles of the blood seem to be the carriers of oxygen from the lungs to the various parts of the body. The prominent reason for this belief is that the serum and salts of the blood have but a very slight power of absorbing oxygen, while the discs condense this gas at once.

448. How much air is used in each act of inspiration, and how much each day? How does temperature and exposure to the open air affect the amount respired?—Upon what does the capacity of the lungs depend? Give the law and its example. 449. How does corpulence affect the capacity of the chest? Give the formula. 450. What is the probable function of the red corpuscles of the blood?

451. Inspirations compared with Pulsations—Quantity of Watery Vapor Given off in Twenty-four Hours—Amount of Carbonic Acid Exhaled—The Amount of Solid Carbon given off.—If we compare the number of inspirations in a minute with the pulsations of the heart, we shall find the proportion of the former to the latter is as one to four or five in the human adult. Every fifth breath is usually deeper than the preceding four, and the time occupied by each respiratory act is about three and a half seconds; and all the blood in the body (when in vigorous exercise) probably is exposed to the air in the lungs every two minutes.

The quantity of watery vapor which is ordinarily exhaled from the lungs in twenty-four hours ranges from sixteen to twenty ounces. The amount of carbonic acid, however, varies much more, being from one to three pounds in twenty-four hours, and the causes of variation are temperature, age, sex, state of health or disease, development of the body, muscular exertion or repose, sleep or watchfulness, and period of the day. “This gas (carbonic acid) contains in every 100 pounds 28 pounds of carbon (charcoal) and 72 pounds of oxygen (gas). Hence the weight of carbon which escapes in this form from the lungs of a full-grown man varies from five to fifteen ounces in twenty-four hours.”

452. Respiration as a Source of Animal Heat.—The value of the function of breathing as a means of producing animal heat, will be considered under the organs for producing heat.

453. Changes in the Food effected by Respiration.—A third object of breathing is to effect such changes in the food that it can be directly converted into the different tissues of the body. Hence the oxygen of the air is a part of the food that we live upon. For although the gluten which is so

451. What is the relative number of inspirations and pulsations of the heart? What length of time is occupied in breathing? What quantity of vapor of water is exhaled in twenty-four hours, and what amount of carbonic acid? How is this amount modified? What weight of carbon or charcoal is given out of the body by the lungs every day?

453. What effect has the oxygen of the air upon the glutinous portion of our food?

largely contained in vegetable food very closely resembles fibrin (which is the form that the nutrient portion of the food must be in before it can nourish the greater part of the body, and especially the muscles), still chemical analysis shows that the gluten must receive another equivalent of oxygen before it is fitted to reproduce the different tissues of the body. And the only way in which this oxygen can be given to the body is either through the lungs or skin.

454. Amount of Air which the Lungs can Contain.—The amount of air which the lungs actually do contain is by no means the amount that should be actually supplied to them. For the air which surrounds the body is very rarely indeed perfectly pure, but is contaminated with the previously exhaled breath, on account of the law of diffusion of gases, which is, that when two gases are brought into contact they immediately commingle with each other. Experiment shows that between 350 and 400 cubic feet of air are actually exhaled during the twenty-four hours; but experience shows that the least quantity which should be allowed for dwelling-houses, shops, and school-houses, should be 800 feet in order to furnish a sufficient supply of oxygen.

CALORIFIC ORGANS.

455. Heat-producing Organs—Theory of Animal Heat.—The organs which produce animal heat are essentially those employed in the act of breathing and the circulation of the blood, and consequently already explained, but the actual method by which it is produced has for a long time perplexed physiologists. The theory which now is most readily accepted makes the function to be a chemico-vital one, or a chemical

What is that element which principally nourishes the muscles? 454. What is the law of diffusion of gases, and what modifying influence does this have on the hygiene of respiration? How many cubic feet of air should be allowed to every in-door laborer or student? 455. What are the heat-producing organs? What is at present the most readily accepted theory of animal heat?

change (oxydization) dependent upon vital energy, being nearly analogous to the burning of a candle or the combustion of wood and coal in the stove.

456. Process of Producing Animal Heat.—As the oxygen in the inspired air enters the lungs and is brought into contact with the blood through the wall of the air-cells, the carbon of the venous blood unites with it, forming carbonic acid, and heat is generated. This is precisely the same thing that takes place in the furnace, where the air enters through the draft supplying the oxygen, and the coal furnishes the carbon, the result of the union being heat. But it is not in the lungs alone that this heat is generated: for we have already seen that the blood is highly charged with oxygen as it passes through the arteries to the various organs of the body. And as it passes through the capillaries in every part of the system, it there receives an equivalent of carbon, the waste of the system producing carbonic acid, in which operation heat is given off. Hence we see that heat is generated not only in the lungs but in every part of the body, and that it is incessantly being produced, which is a reason why the extremities of the body are constantly kept at their proper temperature; for if all the heat were to be generated in the lungs, very frequently the blood would become chilled in its passage to the extreme capillaries. We also see that forced respiration has the same effect as increasing the draft of air into the furnace, and that the fuel of the human system is supplied by means of the food placed in the stomach.

457. Temperature of Human Body.—The temperature of the human system is 98° F., and this it is invariably found to be in all climates and seasons when the individual is in possession of perfect health. So that in most climates the temperature of the body is above that of the surrounding atmos-

456. Describe the process. Is all the heat of the body generated in the lungs? Where in the body is it *not* generated? What is the fuel of the body? Where is the draft?
457. What is the temperature of the human body? How is the heat of the body compared with that of nearly all climates?

phere, and we are constantly giving off heat to the air which envelops us.

458. Manner in which the Body is maintained at its uniform Temperature.—The manner in which the body is kept at the uniform temperature of 98°, is a subject of deep interest. It is partly accomplished by radiation, since the body is ordinarily warmer than the air about it, and also partly by inhaling the cool air into the air passages. It is a well-known principle in chemistry, that, when any substance passes from a more solid to a less solid condition, as from solid to liquid, or liquid to a gas, heat is absorbed, or, in more common language, cold is made sensible. This is seen in the application of water, alcohol, or ether, to the skin, when a sensation of cold is felt, which is owing to the fact that the substance applied is passing from the form of a liquid to that of a vapor. Now the same thing takes place when the perspiration is allowed to evaporate from the surface of the body. The increased flow of blood, as brought about by the exercise, or the high temperature of the surrounding atmosphere, stimulates the vessels of the skin to more energetic action, and sensible perspiration is poured out upon the surface of the body. This, however, is now in contact with the currents of air always present about the body, and it is readily thrown out into a state of vapor, and in accordance with the chemical principle just stated, heat is absorbed from the body producing its uniform temperature.

458a. It should be mentioned here, that of late many experiments have been carried on which seem to show us that the above-mentioned theory of animal heat can not be fully adopted. For it is well known that many chemical combinations besides those of mere oxydation or “burning” produce heat; and many of these processes are constantly taking place in the body. But all the facts hitherto ad-

458. How is the body kept at its uniform temperature? What chemical principle illustrates this view? 458a. Give the result of recent experiments.

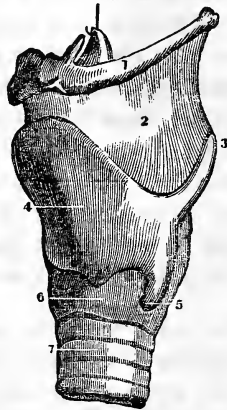
vanced do not by any means entirely overthrow the old theory. They show us that the theory of combustion does not cover the whole ground, but that other causes, as well as oxydation produce animal heat. And we propose the idea that animal heat, like digestion, is a chemico-vital process, that is, a process under the immediate influence of chemical changes, but entirely under the control of the vital principle, since animal heat can not be maintained after death.

ORGANS OF THE VOICE.

DEFINITIONS AND DESCRIPTIONS.

459. The Larynx; its Cartilages.—The Larynx in all animals is the essential organ for the production of the voice. It has also very much the same structure in every animal which has the power of expressing its feelings by the voice. A cartilaginous tube, imperfectly conical, the base directed upwards, made up of distinct portions or segments slightly movable upon one another, and with a certain portion of the channel lengthened into a narrow and elongated opening, constitutes a larynx. In man this organ is made up of seven distinct portions or cartilages, two Arytenoid (pitcher-shaped),

FIG. 255.

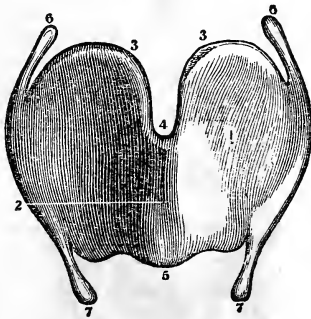


A Lateral View of the Larynx. 1, Os Hyoides. 2, Thyreo-Hyoid Ligaments. 3, Cornu Majus of the Thyroid Cartilage. 4, Its Angle and Side. 5, Cornu Minus. 6, Lateral Portion of the Cricoid Cartilage. 7, Rings of the Trachea.

two Cuneiform (wedge-shaped), one Cricoid (ring-like), one Thyroid (shield-like,) and one Epiglottis (cover to the Glottis). These together form the small prominent portion of the neck known as Adam's apple.

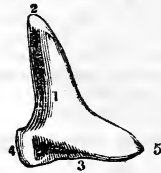
460. Thyroid Cartilage.—Arytenoid Cartilages.—Cuneiform Cartilages.—Cricoid Cartilage.—Vocal Cords.—Ventricle of the Larynx.—Muscles of the Larynx.—The Thyroid Cartilage is so arranged as to form a framework for the movable portions of the organs of the voice, and this is the principal cartilage that forms the Adam's apple. The Arytenoid Cartilages can be moved by the small muscles of

FIG. 256.



A Front View of the Thyroid Cartilage. 1, Left Half of the Cartilage. 2, Anterior projecting Angle. 3, Superior Margin. 4, Its Notch. 5, Inferior Margin. 6, 6, Cornua Majora. 7, 7, Cornua Minora.

FIG. 257.



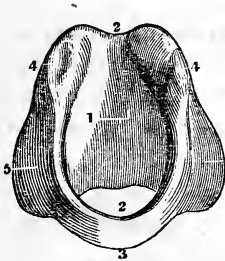
A Posterior View of the Left Arytenoid Cartilage. 1, Its Posterior Face. 2, The Summit. 3, The Base and Cavity for Articulating with the Cricoid Cartilage. 4, Its External Angle. 5, Its Internal Angle.

the larynx. The object of this movement is to relax or tighten the vocal cords, so that the different pitch and quality of voice may be perfected. The Cuneiform Cartilages are about half an inch in length, and enlarged at each extremity. These are sometimes wanting. The Cricoid Cartilage is of a ring-like appearance, and resting directly upon the rings of

459. What is the essential organ of voice in all animals? Give the anatomy of the larynx. Name the seven cartilages. 460. Describe the thyroid and arytenoid cartilages. Describe the cuneiform and cricoid cartilages.

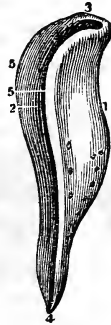
the trachea, being of a little longer diameter than the trachea. The Epiglottis is the most movable of all the vocal cartilages.

FIG. 258.



A Front View of the Cricoid Cartilage. 1, Its Internal Face. 2, The Cavity of the Larynx as formed by this Cartilage. 3, Its Inferior Surface. 4, The little Head or Convexity for Articulating with the Arytenoids. 5, The Surface of the Superior Edge for the Attachment of the Lateral Crico-Arytenoid Muscles.

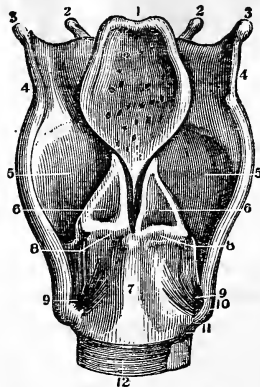
FIG. 259.



A Lateral View of the Epiglottis Cartilage. 1, Anterior or Convex Surface. 2, Posterior or Concave Surface. 3, Superior Margin. 4, Inferior Margin or Pedicle. 5, Its Sides. The Openings of the Muciparous Ducts are also shown.

It in shape resembles a cordate or heart-shaped leaf, attached by its apex to the upper edge of the glottis, and has a wide range of motion, in order to completely close up the passage into the lungs, or leave a free communication between them and the air. It also aids in deadening sounds, as it is suddenly brought down upon the glottis. All these cartilages very

FIG. 260.

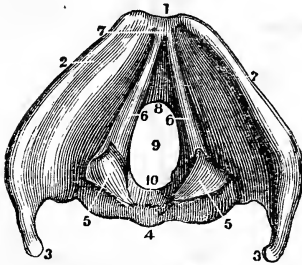


A Posterior View of the Articulations of the Cartilages of the Larynx. 1, Posterior Face of the Epiglottis. 2, Appendices of the Os Hyoides. 3, Its Cornua. 4, Lateral Thyreo-Hyoid Ligaments. 5, Posterior Face of the Thyroid Cartilage. 6, Arytenoid Cartilages. 7, Cricoid Cartilage. 8, Crico-Arytenoid Articulation. 9, Posterior Crico-Thyroid Ligament. 10, Cornu Minus of the Thyroid Cartilage. 11, Anterior Crico-Thyroid Ligament. 12, Ligamentous Portion of the first Ring of the Trachea.

frequently become considerably ossified in males in advanced age.

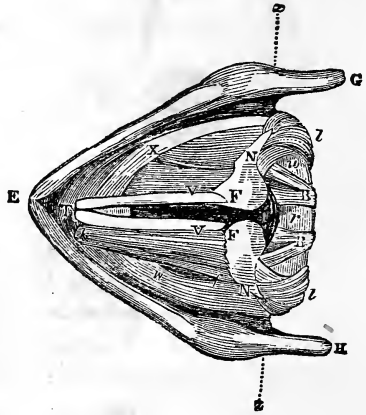
The Vocal Cords or ligaments are folds of white fibrous tissue, covered by mucous membrane, and are made to vibrate when the air is forced over them. Hence ulceration, or any

FIG. 261.



A View of the Larynx from above, showing the Thyreo-Arytenoid or Vocal Ligaments. 1, Superior Edge of the Larynx. 2, Its Anterior Face. 3, Cornua Majores of the Thyroid Cartilage. 4, Posterior Face of the Cricoid Cartilage. 5, 5, Arytenoid Cartilages. 6, 6, Thyreo-Arytenoid Ligaments. 7, Their Origin within the Angle of the Thyroid Cartilage. 8, Their Terminations at the Base of the Arytenoid Cartilages. 9, The Glottis. 10, Anterior Part of the Inferior Surface of the Cricoid Cartilage.

FIG. 262.

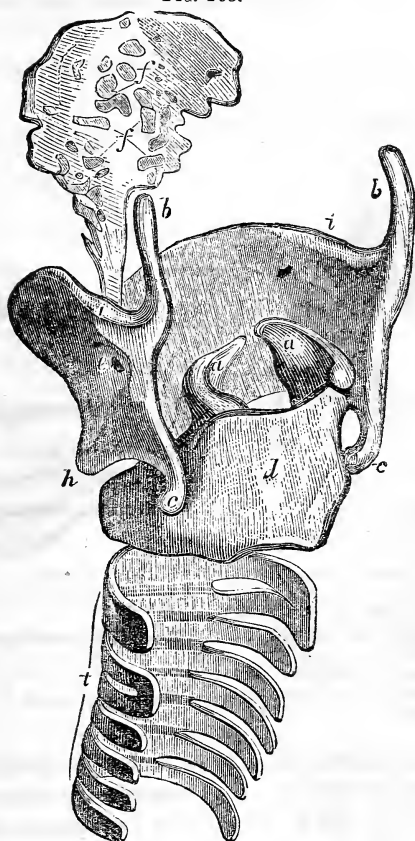


Muscles of Human Larynx. *G. E. H.* Thyroid Cartilage. *r. w. X. w.* Cricoid. *N. F.* Arytenoid. *T. V.* Vocal Ligaments. *N, X, V. K. f. and N. l.* Muscles of Larynx.

alteration in the structure of these cords, will produce hoarseness, a loss of intonation—a whispering—or some change in the quality of the voice. The cords just mentioned are not, however, the only ones that exist in the larynx, for these are the upper ones, while another pair called the inferior cords, exist below the others, leaving a cavity known as the ventricle of the larynx, (Fig. 263, p. 263), which seems essential to the proper production of sound: although there is nothing analogous to it in the ordinary musical instruments. The muscles connected with the larynx are eight: five of them

What is the epiglottis? Of what are the vocal cords composed? What is the ventricle of the larynx? How many muscles belong to the larynx?

FIG. 263.



Cartilages of Larynx and Epiglottis. *a.* Arytenoid. *b.* Its Superior Cornu. *c.* Inferior Cornu. *d.* Cricoid. *f.* Perforation of Epiglottis. *i.* Upper Part of Thyroid. *t.* Trachea. *h.* Tubercle.

pass between the different cartilages, and are of use in regulating the size of the glottis and the tension of the vocal cords, while the three remaining go from the epiglottis to the different parts of the larynx, solely for the purpose of moving this valve to aid in articulation and closure of this passage to the lungs.

Which move the cartilages, and which are distributed mainly to the epiglottis?

FUNCTIONS OF THE LARYNX.

461. *Similarity of the Larynx to a Reed Instrument.*—The larynx, as an organ of sound, very much resembles a reed instrument, or the reed pipes in an organ. For we have the reed, or rather the reeds, in the vocal cords, and the column of air in the pharynx and mouth. This, however, differs from the proper reed instrument by the vibration of free edges of the reed, and also by the power of tightening or relaxing the cords to produce different pitches of tone; for in the hautboy, bassoon, and similar instruments, the tone is regulated by the length of the vibrating column of air, which is controlled by the keys and finger-holes.

462. *Use of the Cartilages.*—The arrangement of the cartilages of the larynx is such as to give form and stability to the organ, and at the same time a firm attachment to the vocal cords, muscles, and ligaments. In male adults these are much larger than in females, since the voice of the former is heavier and of a much lower tone than that of the latter, requiring greater length of vocal cord, and consequently firmer points of attachment.

463. *Organs Essential for the Production of mere Sound.*—The vocal cords, together with the diaphragm, abdominal muscles, and lungs, are all the organs which are necessary for the production of sound. But the quality of sound and articulation are produced and modified very essentially by other parts of the body.

464. *Use of the Cavity in the Frontal Bone.*—The sinus, or cavity in the frontal bone which communicates with the pharynx, is a very important member of the vocal organs, as it imparts resonance to the voice in the same manner as the

461. What kind of instrument does the larynx resemble? What correspond to the reeds? 462. Of what use are the cartilages? Are the vocal cords longest in man or woman? What is the result of it? 463. What organs of the body are necessary for the production of sound? 464. Of what use is the cavity in the frontal bone?

hollow portion of the violin and violincello, or the long tube of brass instruments, gives the proper tone to these instruments. The want of such a cavity for the perfection of the human voice is well appreciated, when a person is suffering with a severe cold in the head, as it is termed. In this case the voice is of an extremely nasal character, because the passage to the frontal sinus is closed up by a thickening of the lining membrane, which prevents a resonance of the tones made in the larynx.

465. Function of the Nostrils in the Voice.—An open passage through the nostrils is also very important for the production of perfect tones of the voice. For when this is obstructed in any way, the head or nasal tone is invariably produced.

466. Function of the Tongue in the Making of Articulate Sound—Not Absolutely Essential.—The tongue is the chief organ of articulation, and in connection with the lips and teeth, the tones made in the glottis are either lengthened or shortened, and otherwise modified to form the different letters. If either of these organs is deficient in substance or function, the articulate sounds are imperfect; as, for instance, the letters T, D, L, F, and S, which require a full development of all the parts for their perfect enunciation. It is, however, stated as a fact, that some people have been known to articulate words with distinctness after the tongue was removed by a gun-shot wound.

HYGIENIC INFERENCES.

467.—1. From the *size* of the lungs we see that they are organs of great importance in the system.

468.—2. Liability of the Lungs to Disease.—On account of their delicate structure and constant use, they are

What produces the talking through the nose, as it is termed? 465. How do the nostrils affect the voice? 466. What use has the tongue in speech? Also the teeth and lips? Is the tongue always absolutely essential? 467. What does the great size of the lungs show us?

liable to disease, and consequently need especial care to keep them in health.

469.—3. Action of the Lungs Essential for their Health.—One important item to secure the health of these organs, is to keep every part of them in action. Hence pressure of clothing, or any thing else that prevents the complete filling of the lungs by breathing, is quite sure to induce disease. For if but a very few of the millions of air-cells contained in the lungs are allowed to lie inactive or useless, nature will attempt their removal by means of the lymphatics, and this removal is often the commencement of fatal disease. Therefore it is a good practice for every one, and especially sedentary persons, several times each day to throw back and downwards the shoulders, and slowly fill the lungs to their utmost capacity, and then permit the air to escape slowly, because in this way every cell in the lungs will be *used*.

470.—4. Pure Air is Essential to Healthy Lungs—Life Depends on Breathing Pure Air.*—All mechanical and chemical impurities of the air inhaled induce and aggravate disease. Indeed, the most important hygienic rule for the lungs is to breathe pure air. Mechanical impurities, such as dust and vapors, are eminently injurious, but not so much so as the chemical impurity, carbonic acid, which comes from the exhalations of men and animals, and the burning of

* **BLACK HOLE OF CALCUTTA.**—One of the most awful instances of suffocation on record, is connected with what is known as the Black Hole of Calcutta. When Calcutta was taken by the Indian forces, the British garrison, numbering 146 men, were confined as prisoners of war in the dungeon of the fortress, a room only eighteen feet square, and intended only for confinement of two or three men. This dungeon had only two small windows, both upon one side of the building, in front of which was a verandah that aided greatly in impeding whatever slight circulation of air there might be. Besides the great heat of a July night, on which this occurred, conflagrations were raging near the fort which greatly increased the heat. Very soon after the men were confined, the suffering became intolerable, and the dungeon was a scene not only of the intensest anguish, but of frightful delirium of most of the inmates. By eleven o'clock the men began to die very rapidly, and owing to the intense heat and overpowering stench caused by these exertions of the frantic soldiers, in the morning at six o'clock, when the doors were opened, but twenty-three were alive, who were either stupefied or raving.

463. What does their delicate structure show us? 469. What is said of the necessity of action for the lungs? What habit is of great service, and why is it? 470. How do impurities of the air affect the lungs? What kind of impurities are the most injurious? What is one of the principal sources of disease in civilized society?

all combustible substances. And it is safe to say, that the greater the care we take to ventilate our rooms, and in every way to breathe pure air, the longer shall we live and with the least amount of pain and disease. Breathing impure air is one of the greatest natural evils to which civilized society is subject, and destroys more lives than almost any other.

471.—5. We need Pure Air by Night as well as by Day.—Hence we see that the lungs need pure air all the time, by night as well as by day—in the sitting-room, the eating-room, and the bed-chamber, the school-house, the meeting-house, rail-car, and steamboat, if we would do our utmost to ward off disease and death.

472.—6. Capacity of the Lungs Affected by Posture.—The capacity of the chest is greatly influenced by our position in sitting or standing, and the amount of use to which it is subject. If the shoulders are thrown forward or the body is bent in the same way, the lungs are compressed, and can not be filled to their full capacity. Hence special pains should be taken to maintain the body in an erect posture, and to keep the chest thrown forward.

473.—7. Pure Air is often a Medicine.—In most diseases the breathing of pure air is important for restoration to perfect health, since there are often some impurities in the blood or system which are removed mainly by pure air. So that the rule of supplying pure and warm air to the sick room should be rigidly observed.

474.—8. Warm and Moist Air the Best for a Healthy Person.—The air best adapted for breathing should contain but a small amount of moisture, nor should it be perfectly dry, especially that which comes from intensely heated iron surfaces. Cold and damp air is apt to bring on irritation of the mucous membrane, producing coughs and colds.

475.—9. Capacity of the Lungs may be Increased.—

471. When and where do we need pure air? 472. How is the capacity of the lungs modified? What of the necessity of an erect posture in sitting or standing? 473. Why is pure air so important in sickness? 474. What is the best quality of air for breathing?

The lungs, if compressed by disease or improper clothing, and even in many cases of so-called perfect health and soundness, can be very much enlarged in their capacity. This can be done by loud reading, or by the simple act of filling the lungs with air to their utmost capacity several times each day, after the manner mentioned under inference 3d. If this healthy habit be kept up for a few years even by some considerable effort, nature will at length take up the habit, and we shall ultimately be found involuntarily filling the lungs with pure air, and thus fix upon ourselves a hygienic habit of great importance in preserving health, and of great value in repelling disease.

476.—10. Colds and Coughs—Treatment—Sympathy between the Different Parts of the Mucous Membrane.—Colds and ordinary coughs are affections of the mucous membrane, and generally only of the lungs, pharynx, and nostrils and air passages leading to the lungs. They are often produced by obstructions in the vessels of the skin, and hence a great relief in many instances for a cold, and often a cure, is to remove this obstruction by stimulating these vessels to powerful action, as in sweating. This effect is produced by the sympathy which exists between the skin and mucous membrane, one often performing the function of the other for a short time. The mucous membrane also has a remarkable sympathy between its different parts; and hence even the portions which are unaffected by the cold should be kept as quiet as possible, by taking, for instance, but little food into the alimentary canal, and that of a liquid character, so that it may be readily taken up by the absorbents of the stomach.

477.—11. Injurious Effects of Wearing Shawls by Gentlemen.—From the fact that whatever compresses the chest greatly tends to bring on diseases of the lungs, we in-

475. How can the size of the lungs be perceptibly increased? 476. What are colds and common coughs? How are they often induced? What is their best treatment? What is remarkable about the sympathy between the skin and the mucous membrane? 477. How are shawls often injurious to the lungs?

fer that the wearing of shawls by gentlemen, inasmuch as it requires a drawing forward of the shoulders to make them thoroughly cover the body, compresses the lungs, and therefore is highly injurious. Moreover, it makes a person round-shouldered, and thus gives the appearance of premature old age.

478.—12. *The Neck to be Dressed Lightly.*—From the many movements which are made by the larynx in speaking, we infer that it is a matter of great importance that the neck in health should be always loosely dressed. For tight cravats and neckcloths are sure to obstruct the proper function of this organ, and bring on irritation, which may end in bronchitis or consumption.

479.—13. *A Strong Voice Demands Vigorous Exercise of all the Body.*—We learn also that they who would have the strongest and best developed voices for speaking and singing should pay special attention to the general health, and particularly to muscular exercise in the open air, because the voice depends so much more upon the healthy condition of the whole body than it does upon the healthy or unhealthy condition of the larynx.

480.—14. *Great Aid in Speaking can be Acquired by Enunciating the Simple Vowel Sounds.*—Experience shows that great aid can be given to those who would secure pure and correct tones in speaking by slowly but distinctly enunciating the simple vowel sounds of the English language. This not only strengthens the organs, but it gives a proper training to the laryngeal muscles, so that in the composition of vowels and consonants the muscles will contract to their proper amount, and only to that.

478. What clothing should be given to the neck? What is one source of bronchitis?
 479. How is the voice made and kept clear and strong? 480. How can poor speakers
 and readers make themselves superior ones?

COMPARATIVE PNEUMONOLOGY.

RESPIRATORY ORGANS.

481. *Trachea*.—The *Trachea* in some animals, such as the horse and cow, consists of complete rings, while in many animals they are only portions of rings, whose free extremities are united by membrane. In man these rings number from seventeen to twenty, in the whale from seven to twelve, in the carnivora from thirty to forty, and in some camels one hundred and ten.

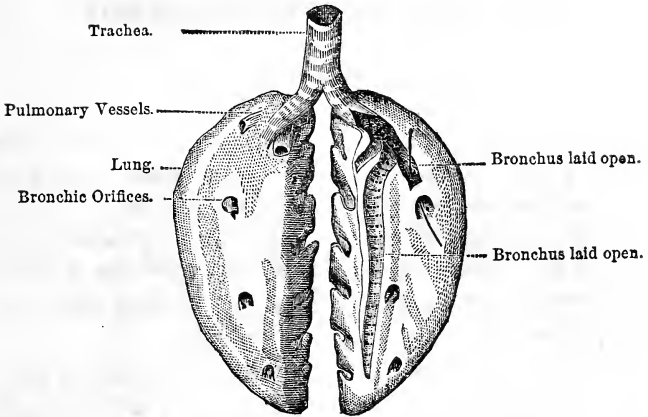
482. *Bronchi*.—The *Bronchial Tubes* are usually two in number, but in the ruminants, the dolphins, and some other mammals there are three. This third tube is always the smallest, and passes to the right lung.

483. *Lungs*.—In the horse the lungs are undivided, but in most quadrupeds the number of lobes is greater than in man. In the marmot and hamster there are five in the right, and three or four in the left lung. In the musk deer the right lung is nearly twice the size of the left. The terminal air-cells of all these animals correspond in size very nearly with those of man. The lungs are proportionally the largest in the more powerful carnivora, and smallest in the weak herbivora, and the red blood corpuscles are much more abundant in the blood of the former than of the latter.

484. *Respiration of Birds. Lunglets*.—In Birds the respiratory apparatus, like that of Insects, extends through a large part of the body, (Fig. 264, p. 271), not only in the lungs proper, but through the channeled bones which are lined with a membrane for purifying the blood. (Fig. 265, p. 271.)

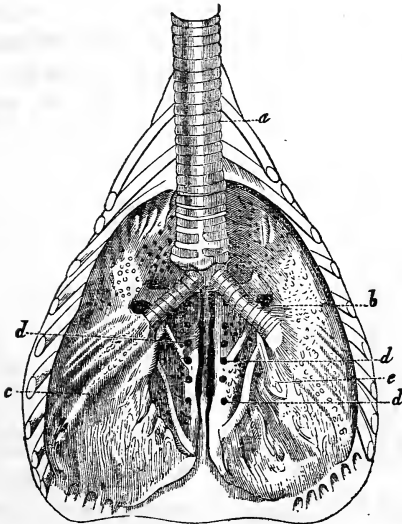
481. How does the trachea in many of the lower animals differ from that of man? What is the relative number of rings in each? 482. What is said of the number of the principal bronchial tubes? 483. What of the number of lobes in many quadrupeds? In what animals are the lungs largest, and in what ones weakest? 484. How is the respiratory apparatus of birds and insects alike?

FIG. 264.



Lungs of a Bird.

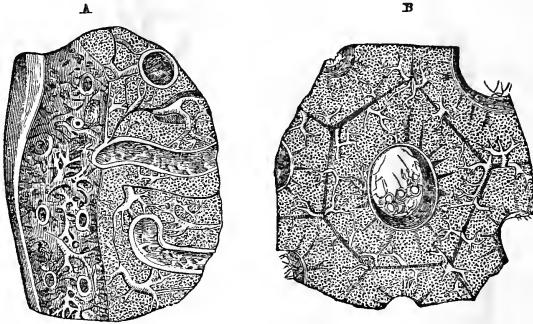
FIG. 265.



Pulmonary Apparatus of a Pigeon, as seen on removing the Anterior Wall of the Thorax. *a.* Trachea. *b.* Bronchi. *c.* Lungs. *d.* Apertures of Communication with Air-Cells.

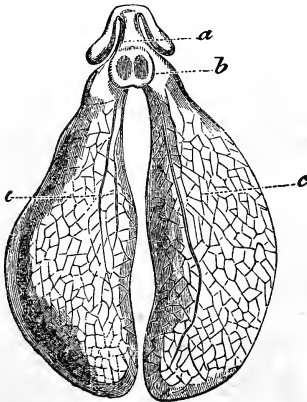
Large air-sacs are also contained in the abdomen, freely communicating with the lungs, and acting as reservoirs for them. A minute examination of the structure of these organs shows

FIG. 266.



Lunglet of a Fowl. A. Section passing in the direction of the Bronchus. B. Section cutting it across.

FIG. 267.



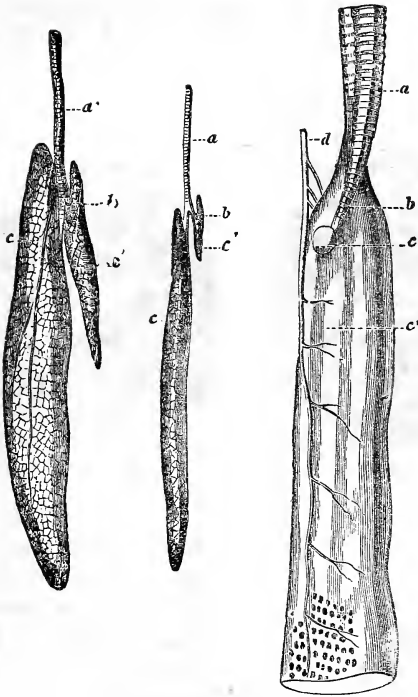
Lungs of Frog. a. Hyoid Apparatus. b. Cartilaginous Ring. c. Lungs Proper.

that they are made up of lobules or lunglets, each of which has its own system of vessels, and but little communication with the other lunglets.

485. Lungs of Reptiles. — The Hiss of Serpents. — Mechanism of Respiration. — The Lungs of the several orders of Reptiles are for the most part capacious sacs, the extent of surface in which is but little increased by smaller sacs or vessels within them. In the Frog,

What appendages do they have which do not exist in quadrupeds? 435. What are the lungs of reptiles?

FIG. 268.

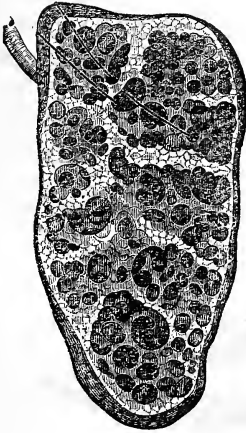


Lungs of Serpents. *a.* Trachea. *b.* Bronchi. *c.* Right Lung. *c'.* Left Lung. *d.* Pulmonary Artery.

for example, the bronchi terminate in capacious cavities, upon the sides of which are the pulmonary blood-vessels. In many serpents the pulmonary apparatus consists of a long cylindrical sac or lung upon the right side of the body, the corresponding one on the left side being merely rudimentary, as seen in Fig. 268. Serpents are capable of expiring and inhaling large quantities of air, which compensates for the want of a great internal surface of lungs. And the peculiar hiss made by them is simply a prolonged expiration of air from the lungs.

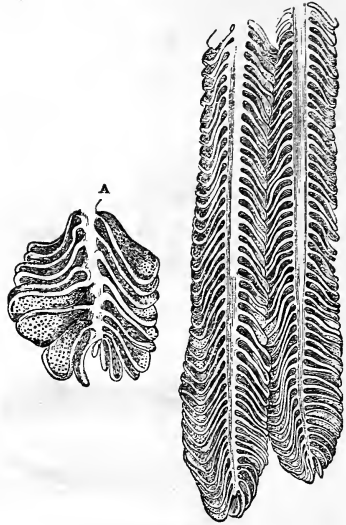
How is it in frogs and serpents? What makes the hiss of serpents?

FIG. 269.



Lung of Turtle laid open.

FIG. 270.



Gills of Eel. A. Enlarged Portion.

In aquatic serpents the amount of air contained in the body tends to make it buoyant, and at the same time supplies the wants of the animal during a long immersion. In frogs and many of the class reptilia the air is forced into the lungs by a process similar to that of swallowing. Taken as a whole, this order is remarkable for the feebleness of its respiratory actions, and the length of time which the function can be suspended without injury. The temperature in which the animal lives, however, greatly modifies the amount of air exhaled and inhaled.

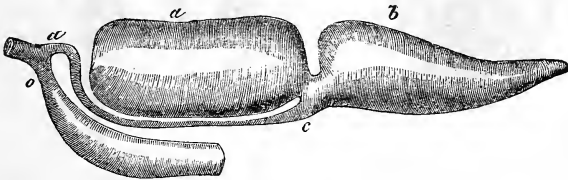
486. Gills of Fishes.—The Respiratory apparatus of Fishes consists of Gills for procuring the air contained in water. The Gills are fringes of minute bronchial tubes suspended from cartilaginous and bony arches, that are situated

How do frogs inspire? What effect has the temperature upon the respiration in this class of animals? 486. What are the organs of respiration in fishes? Describe the gills.

just behind the lower jaw. "These are disposed, in most fishes, in fringed laminae, which are set close together like the barbs of a feather, and are attached on each side of the throat in double rows, to the convex margins of four or five long, bony, or cartilaginous arches, which are suspended from the hyoidean arch."

487. Air-Bladder.—Another organ which perhaps claims attention here, is the Air-Bladder. This is a small shut sac—sometimes nearly subdivided into two or more sections by

FIG. 271.



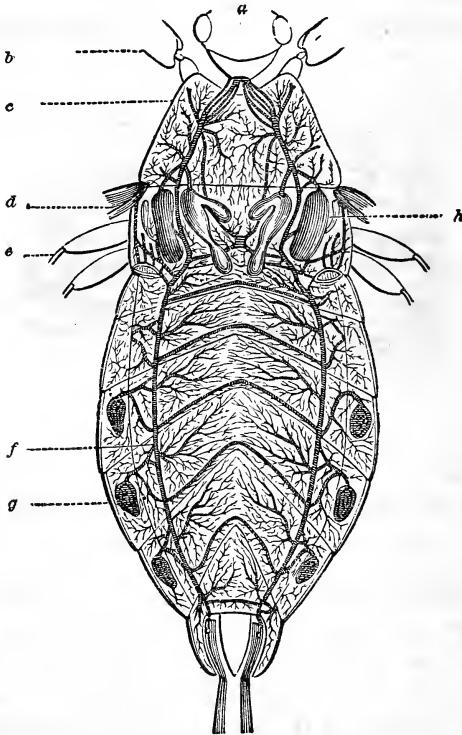
Air-Sac of Fish (Carp). *a. b.* A Divided Form. *c. d.* A Tube connecting it with the Esophagus *e.*

a membranous division—which lies near the middle of the back. In most cases it has no connection with any other organ, but sometimes has an opening into the esophagus or stomach. The uses for which it has been supposed to exist, are to enable the fish to alter its specific gravity, and also to aid in respiration in some manner. It has also been conjectured that it aids the sense of hearing, since it is in direct connection with the auditory apparatus. It is filled with atmospheric air, with greatly varying proportions of oxygen and nitrogen. Some fishes that leave the water occasionally and crawl over the land, have a cavity in the side of the head for water, which is in contact with a respiratory apparatus, and thus the fish can live for some time out of its native element.—WYMAN.

487. Describe the air-bladder. What does it sometimes communicate with? Give its probable uses. What is it filled with?

488. Trachea of Insects.—Spiracles.—Mechanism of Respiration.—Wisdom of this Arrangement.—The respiratory vessels of Insects are analogous to those of birds in that they extend through a large part of the body.

FIG. 272.



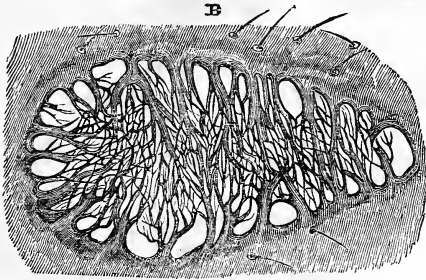
Trachea of Water-Scorpion. *a.* Head. *b.* First Pair of Legs. *c.* First Segment of Thorax. *d.* Second Pair of wings. *e.* Second Pair of Legs. *f.* Tracheal Trunk. *g.* One of the Stigmata. *h.* Air-Sac.

The essential organs are Tracheæ or air-vessels, which open upon the sides of the body, and freely communicate with one another. Air sacs are found in the front parts of the body

488. What are the essential organs of respiration in insects? Whereabouts in the animal are the tracheæ found?

of some insects, and the tracheæ are very minute, ramifying through the most delicate organs of the body, which plan allows a rapid aeration of the blood, and greatly assists in diminishing the specific gravity of the animal. The openings upon the surface of the body are called Spiracles or Stigmata, and are either oval or made in the shape of a slit, as is seen in the adjoining cut. In the soft-skinned insects they

FIG. 273.



Spiracle of Common Fly.

are surrounded by a ring of cartilage, to prevent their closing by ordinary accidents or pressure, and all spiracles are protected by a kind of sieve or grating, made up of hairs extending from either side of the aperture, which keeps out dust, that would otherwise enter with the air and stop the passage. The interchange of air is effected by the enlargement and contraction of the abdomen. The rings, (or skeleton), which surround the abdomen, are seldom inflexible, but are made up in one part of membrane, and the horn-like ends are brought together by muscular contraction, by which means expiration is effected. The enlargement or inspiration is accomplished by the simple elasticity of the encasing rings of the body, as well as of the trachea. Hence, fullness is the natural or passive state of the respiratory or-

What are the spiracles? How are they sometimes protected? Give the mechanism of respiration.

gans, as was seen to be the case with birds. Still another way in which respiration is effected, is by the sliding of one ring inside the next one, like the joints of a hand telescope, and their return by the elasticity of the tissues of the body. And we can not fail to observe the beautiful design of the Creator, when, though he furnished but a limited circulation of fluid, yet fully compensated for it by introducing the air in minute tubes to the very center of every tissue.

489. Crustaceans.—These animals breathe mostly by gills. The Myriapods have proper tracheæ, though with some respiration is chiefly cutaneous, that is, directly through the skin. The Arachnoid or Spider tribe sometimes have tracheæ and sometimes even lungs. The gills of the Crustaceans are situated in different parts of the body, more especially on the feet.

490. Molluscs.—In the Acephala the blood before returning to the heart passes through a bronchial organ or gill, which opens and closes for the ingress and egress of water. Some of the Cephalophora have gills; others lungs, and others a system for the circulation of water containing air, through different parts of the body. The Cephalopoda all respire by gills; but they have also an aquiferous system.

491. Radiates.—“The simple exposure of the surface of a jelly-fish or polyp to the action of the fluid around it is sufficient to carry on all the changes which take place in its simple kind of respiration.”—Prof. J. WYMAN. Nearly all the Radiates have such an aquiferous system. But many of them have other organs for breathing. The Echinoderms have gills; also sometimes their organs of prehension and locomotion form a respiratory apparatus.

What instance of compensation is shown here? 489. Do any crustaceans breathe by gills? 490. What is the breathing apparatus of molluscs? 491. What is the respiratory apparatus of radiates?

THE SOUNDS PRODUCED BY ANIMALS.

492. Among vertebrates the production of vocal sounds is confined to the air-breathing classes, since no fish or gilled animal is able to make any sound by means of the special organs which are provided for that purpose in other animals.

493. Laryngeal Pouches, or Sacs.—Nearly every mammal can make some vocal sound, and the structure of the larynx in all very closely resembles that of man. The howling apes present the most striking difference in these organs. They have pouches, or laryngeal sacs as they are called, connected with the larynx, which increase the loudness of the voice simply by the resonance of the voice in these cavities.

494. The Two Larynges of Birds—The Trill of Birds.—In birds the vocal organs are somewhat different from those of man. There is in them a larynx, called the superior larynx, at the summit of the trachea, which seems designed mainly for the ingress and egress of air. But the vocal sounds for which birds are so remarkable are made by what is called the inferior larynx, which is situated at the lower extremity of the trachea. This is most complex in birds which have the greatest powers of song. The two or three lower rings of the trachea are usually consolidated into one, and in the interior a cross bone runs from front to back which has upon its upper edge a small membrane of a crescentic-shape, which is so lax that it can freely vibrate when the air is made to pass rapidly over it. This in its action, is analogous to the reed of the clarinet or melodeon. It is by the vibration of this membrane that the peculiar trill of many singing-birds is so beautifully executed. The intensity of the

492. What vertebrates alone can make vocal sounds? 493. What is said of the structure of the larynx in all mammals? What is the peculiarity among the howling apes? 494. How many larynges have birds? Give the function of each. What peculiarity in the lower part of the trachea?

tune is greatly increased by the construction of the trachea and bronchi. "Birds whose voices have a very extensive musical scale are able to shorten and lengthen their wind-pipe considerably, and to that end have very thin wings and large membranous interspaces."

495. *Larynx of Reptiles.*—Reptiles have an imperfect kind of larynx, which is located at the point where the trachea opens into the pharynx. The only sounds which they can make is the croak of the frog and hiss of the serpent, turtle, or lizard. The common Frog has two vesicles or little bags behind the angle of the mouth, which are much distended at the beginning of summer and at pairing time, which accounts for their loud croaking at these seasons.

496. *Sounds Made by Insects.*—As we descend the scale of animals, we find in no other a larynx or organ of voice, and hence all the sounds made by them are not the sounds of the voice, but simply noises which are for the most part made by their extremities. The sounds made by insects such as approach most nearly to those of vertebrate animals, are produced by vibrations of a membranous plate situated just over the spiracles. And in general those insects that fly the most rapidly, and whose wings move the fastest, make the most noise, while those which move more slowly seem only to fan the air with their wings. Other sounds are produced by mastication. Thus, an army of locusts, when eating, makes a sound which very much resembles the noise of a crackling fire. A genus of ants make a sound by striking some hard substance with their mandibles, or arm-like appendages. A species of beetle that bores in old timber (called the death watch) makes a sound in a similar way, and if it be answered by its mate the signal will be repeated: but if no answer be given, the animal changes its position before it produces its "tick" again. The shrill sound of the grasshopper and the

What use is it? What construction increases the intensity of their tones? 495. What is the larynx of reptiles? What is their voice? 496. Do insects have a larynx? In what different ways are sounds made by insects?

so-called locust is made by rubbing together the anterior pair of wings, upon the nervures or framework of the wings, on which are found file-like edges. In a large species of this kind living in Brazil, which has a drum-like appendage under the wings, the sound can be heard a mile; and if a man of ordinary stature possessed a proportionably loud voice, he could be heard all over the world.

497. Sounds of Mollusca.—Among the Cephalopods there are a few individuals which are able to make a clear, bell-like sound, but the origin of it is unknown.

497. What is said of sounds made by molluses ?

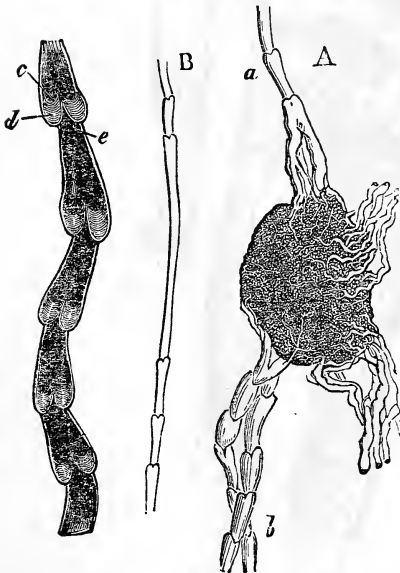
CHAPTER SIXTH.

ICHOROLOGY, OR HISTORY OF THE ORGANS OF SECRETION.— THE LYMPHATIC AND SECRETORY SYSTEM.

DEFINITIONS AND DESCRIPTIONS.

498. The Body is Constantly Undergoing a Change.— We have seen that the human body is constantly undergoing changes in its constituent parts. The nutrient portion of the food designed for the support and growth of the different tissues is conveyed by the lacteals to the left sub-clavian vein, where it enters the general circulation; while the particles which are constantly set free in all parts of the body are, by vessels of the same general character, called lymphatics, conveyed to the blood and thence to the lungs.

FIG. 274.



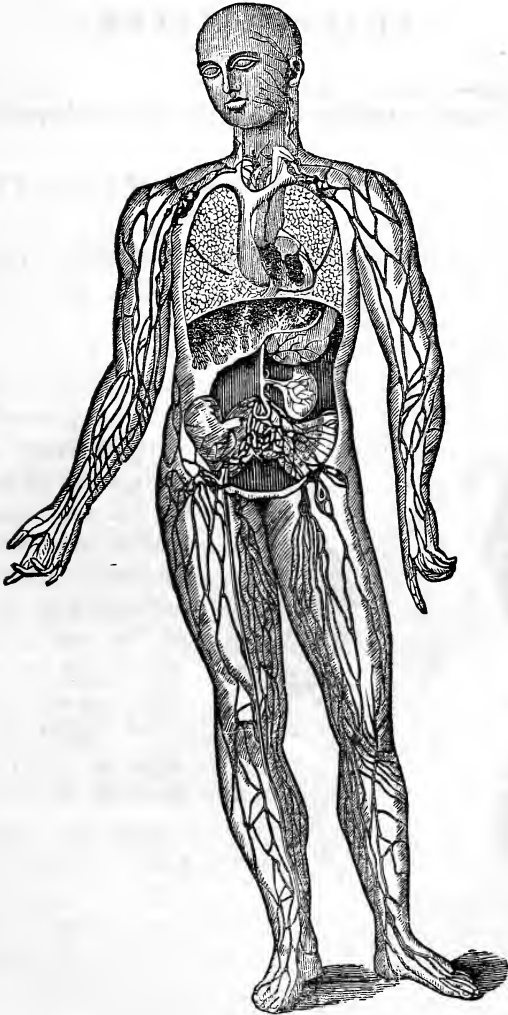
A, a, Deep-seated Lymphatic Gland. a, b, Lymphatics which Supply and Empty the Gland. B a, Superficial Lymphatic, less complex in structure. c, a, Lymphatic laid open to show the Valves, c, d, e.

499. The Lacteals a Variety of the Lymphatics.— A more correct arrangement, however, brings both sets of absorbent vessels under the class of lymphatics, making the lacteals only a variety, since their

of lymphatics, making the lacteals only a variety, since their

495. How is it that the body is constantly undergoing change? 499. What may the lacteals be properly called?

FIG. 275.

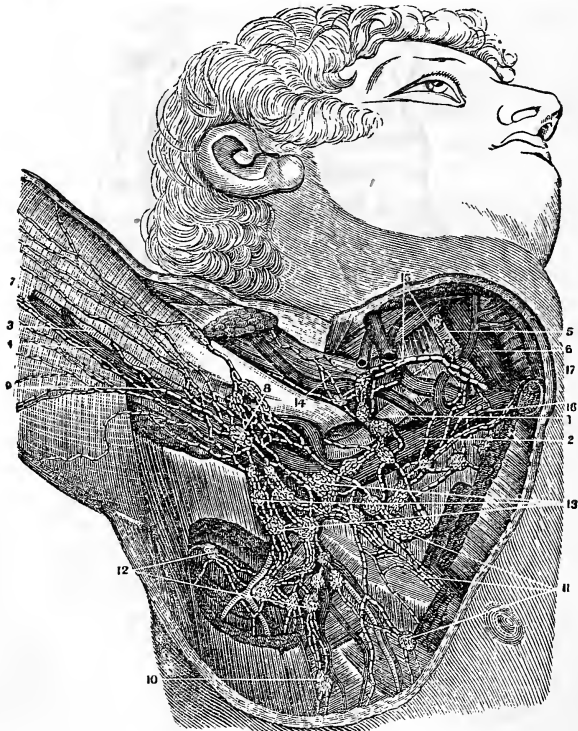


The Lymphatics of the Body.

chief difference consists in the kind of material they convey, and not in structure or function.

500. The Lymphatics—Their Similarity to Veins and Arteries—Their Appearance when Injected with Mercury.—The lymphatics are very delicate, minute and transparent vessels like the capillaries, remarkable for their uniformity of

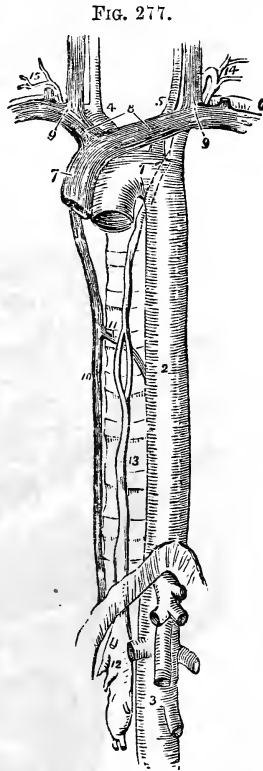
FIG. 276.



A View of the Vessels and Lymphatic Glands of the Axilla. 1, The Axillary Artery. 2, The Axillary Vein. 3, The Brachial Artery. 4, The Brachial Vein. 5, The Primitive Carotid Artery. 6, The Internal Jugular Vein. 7, The Sub-Cutaneous Lymphatics of the Arm at its Upper Part. 8, Two or three of the most inferior and Superficial Glands into which the Superficial Lymphatics empty. 9, The Deep-seated Lymphatics which accompany the Brachial Artery. 10, The Lymphatics and Glands which accompany the Infra-Scapular Blood-Vessels. 11, The Glands and Lymphatics accompanying the Thoracica Longa Artery. 12, Deeper-seated Lymphatics. 13, The Axillary Chain of Glands. 14, The Acromial Branches of the Lymphatics. 15, The Jugular Lymphatics and Glands. 16, 17, The Lymphatics which empty into the Sub-Clavian Vein near its junction with the Right Internal Jugular Vein.

size, of a knotted appearance, and very frequently dividing into two nearly equal branches. Like veins and arteries, they have three coats, with folds of the inner coat for the formation of valves, giving them a knotted appearance. They commence in a minute net-work in nearly every organ of the body, and soon unite into a few large trunks which take a direction towards the veins in the lower part of the neck. This net-work is so exceedingly delicate, that when filled with mercury it presents the appearance of a sheet of silver. The necessity of such an immense number of these vessels arises from the constant liberation of the waste particles of matter which need to be removed as soon as possible, that the deposition of new particles may not be prevented.

501. Lymphatic Glands.—
As the minute lymphatics unite into larger trunks, they

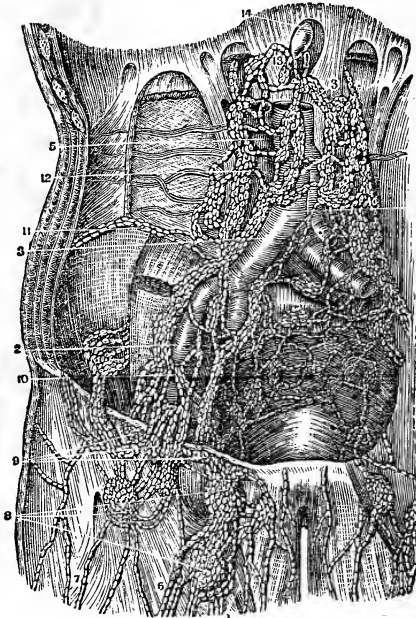


A View of the Right Lymphatic Thoracic Duct. 1, Arch of the Aorta. 2, Thoracic Aorta. 3, Abdominal Aorta. 4, Arteria Innominata. 5, Left Carotid. 6, Left Sub-Clavian. 7, Superior Cava. 8, The two Venæ Innominatæ. 9, The Internal Jugular and Sub-Clavian Vein at each side. 10, The Vena Azygos. 11, The Termination of the Vena Hemi-Azygos in the Vena Azygos. 12, The Receptaculum Chyli: several Lymphatic Trunks are seen opening into it. 13, The Thoracic Duct dividing, opposito the Middle Dorsal Vertebra, into two branches, which soon re-unite; the course of the Duct behind the Arch of the Aorta and Left Sub-Clavian Artery is shown by a dotted Line. 14, The Duct making its turn at the Root of the Neck and receiving several Lymphatic Trunks previous to terminating in the Posterior Angle of the Junction of the Internal Jugular and Sub-Clavian Veins. 15, The Termination of the Trunk of the Lymphatics of the Upper Extremity.

500. Describe the lymphatics. How many coats have they? What is said of the network which they make? Why the necessity of such a multitude?

pass through small bodies, varying in size from a mustard-seed to a pea, which are called lymphatic glands, whose design is not yet clearly understood. They then pass upwards towards the heart as already mentioned, those of the left side of the body emptying themselves through the thoracic duct, while those of the right side enter a tube running parallel to this, called the Right Lymphatic Duct. 13, Fig. 277.

FIG. 278.

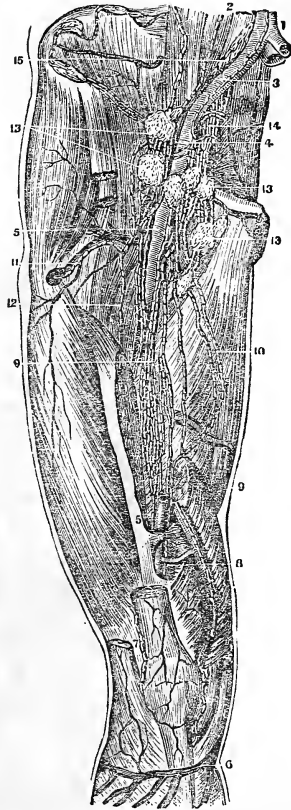


A Front View of the Femoral, Iliac, and Aortic Lymphatic Vessels and Glands. 1, Saphena Magna Vein. 2, External Iliac Artery and Vein. 8, Primitive Iliac Artery and Vein. 4, The Aorta. 5, Ascending Vena Cava. 6, 7, Lymphatics which are alongside of the Saphena Vein on the Thigh. 8, Lower Set of Inguinal Lymphatic Glands which receive these Vessels. 9, Superior Set of Inguinal Lymphatic Glands which receive these Vessels. 10, The Chain of Lymphatics in Front of the External Iliac Vessels. 11, Lymphatics which accompany the Circumflex Iliac Vessels. 12, Lumbar and Aortic Lymphatics. 13, Afferent Trunks of the Lumbar Glands, forming the Origin of the Thoracic Duct. 14, Thoracic Duct at its commencement.

501. Describe the lymphatic glands. What is the right lymphatic duct?

502. Material Absorbed by Lymphatics—Effect of Various Substances Applied to the Skin—Nutriment Sometimes Introduced through the Skin—Thirst Quenched by Wet Clothes.—These vessels not only remove useless particles, but absorb substances applied to the skin, although some maintain that this is done by the veins alone. And this is sometimes an effective method of administering medicines which it is not expedient to introduce through the mouth and nostrils, thus producing a desired effect upon the circulatory and venous systems without offending, or in any manner affecting the senses or feelings of the person taking the medicine. For instance, spirits of turpentine rubbed upon the hands of many persons, and green leaves of tobacco placed upon the abdomen, will often produce

FIG. 279.



A Front View of the Deep-seated Lymphatics of the Thigh. 1, Lower End of the Aorta. 2, Primitive Iliac Vein. 3, 4, External Iliac Artery and Vein. 5, Femoral Artery. 6, Section of the Femoral Vein. 7, Vena Saphena on the Leg. 8, Lymphatics near the Knee. 9, Lymphatics accompanying the Femoral Vessels. 10, Deep Lymphatics going from the inside of the Thigh to the Glands in the Groin. 11, Lymphatics of the External Circumflex Vessels. 12, Lymphatics on the outer side of the Femoral Vessels. 13, A Lymphatic Gland always found outside of the Vessels. 14, A collection of Vessels and Glands from the Internal Iliac Vessels. 15, The Lymphatics of the Primitive Iliac Vessels.

502. What do the lymphatics absorb? What value of this fact at times? Give a common effect of tobacco and turpentine rubbed upon the skin.

distressing sickness. Mercury, too, rubbed vigorously upon almost any part of the skin, will in a short time produce salivation, because the minute globules of this metal are forced through the pores of the skin, and are absorbed by the lymphatics. In some cases where disease has so affected the mouth or passage to the stomach as to prevent the introduction of food, life has been maintained for a considerable time by nutriment introduced through the skin, by means of a bath of warm milk. Shipwrecked sailors in an open boat and deprived of fresh water, can for some time partly assuage their thirst by wetting their clothes with salt water, or better still, by a thorough wetting during a rain storm.

503. Poisons Introduced through the Skin by the Lymphatics.—The poisoning which frequently occurs from the contact of the skin with sumach or ivy, is owing to the absorption of poisonous influence by these vessels. Animal poisons, too, such as the venom of mad dogs, serpents, and insects, are introduced to the general system by the lymphatics.

504. Pressure Increases their Action.—Pressure greatly increases the action of the lymphatic vessels. This is seen in a broken limb which has been tightly bandaged, when the muscles become very small from the removal of the tissue by the excessive action of the lymphatics.

505. Venous Absorption—Radicles.—Besides lymphatics, the small veins perform the function of absorption. It is easily seen that these can perform the same office as the lymphatics, since both of them carry their fluids to the heart for purification, and no other use is made of them on their way thither. These radicles, or small veins, perform a very important function in the stomach by the rapid absorption of the watery portion of all liquids, and its conveyance to the gen-

Is nutriment ever conveyed into the system in this way? Can thirst be quenched in this way? 503. Do the lymphatics ever introduce poison into the system? 504. How does pressure affect the action of lymphatics? What example of it? 505. What is said of absorption by the veins? What important service do the radicles perform in the stomach?

eral circulation without passing through the circuitous course taken by the food.

506. Effect of Moisture upon the Lymphatics.—Moisture stimulates these absorbent vessels to a morbidly vigorous action. Hence a person surrounded by a moist atmosphere or immersed in water itself, will acquire additional weight. And as an excessive use of the eliminating organs of the system is injurious, locations for houses should be selected as far as possible on dry places, and not on wet or low land where heavy fresh water fogs prevail. For the same reason damp clothing injures the body, because it unduly stimulates the lymphatics.

507. Amount of Matter taken up by the Absorbents.—The amount of Chyle and Lymph poured into the blood by the lymphatics and radicles is about one third of the whole amount in the body.

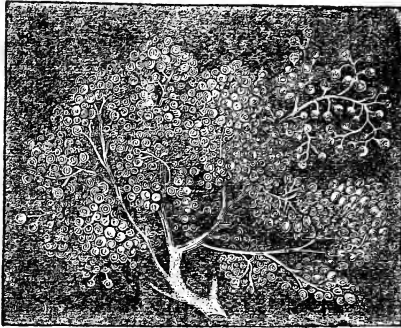
ORGANS OF SECRETION.

508. Follicles and Glands.—Character of Secretions.—Size of Follicles.—The organs which perform the office of secretion in the body are Follicles and Glands. The former of these are small bodies in the form of sacs or tubes, existing for the most part in the skin and mucous membrane, one end of which opens upon the surface of the membrane, for the discharge of its secretion. The secretion poured from these varies in consistency from the thick wax of the ear, to the limpid juice of the stomach. The follicles vary also in size from tubes perceptible to the naked eye down to those $\frac{1}{16}$ th of an inch in diameter.

509. Glands.—The Glands are soft solids of various sizes (the liver the largest) made up of lobules or small bodies of

506. How does moisture affect the lymphatic action? How do damp clothes injure the wearer? 507. What is the amount of matter taken up by the absorbents? 508. What is the anatomy of the follicles? Of what character is their secretion? What is their size? 509. What is a gland?

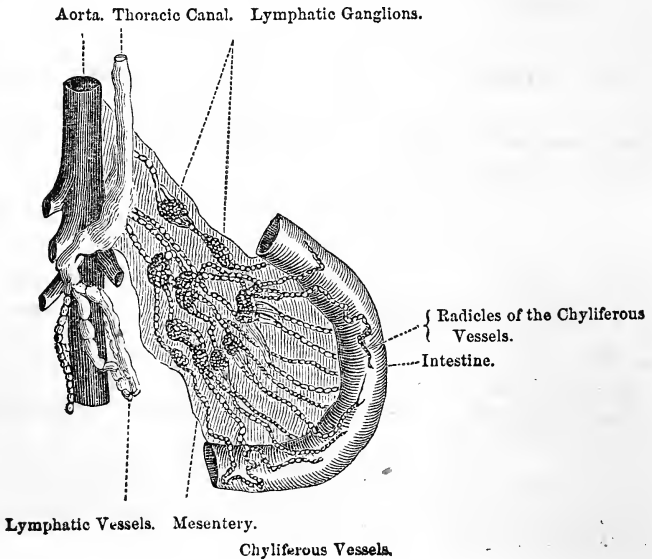
FIG. 280.



Intimate Structure of a Gland (the Parotid).

minute proportions, each of which has an artery, a vein, and a duct to carry away the secretion. These ducts unite with one another, until they form one tube called the principal outlet of the organ. In some glands these lobules are quite

FIG. 281.



large—one fourth of an inch in diameter—while frequently they are nearly the size of a mustard seed. The color is also various. That of the liver is a dark red, the pancreas of a pale white or gray, the little gland in the inner angle of the eye pink, and the kidneys a reddish yellow.

510. *Function of Secretion.*—The function performed by these vessels is an exceedingly curious, and not easily explained phenomenon. For from the blood are eliminated by the various secretory organs, bile, saliva, perspiration, tears, etc., none of which exist there *as such*, but they seem to be formed from the chemical elements in the blood by the glands themselves.

511. *Effect of the Emotions upon the Secretions.*—The mental emotions greatly affect the secretions. A person in fear is often covered with a cold perspiration, and in some persons in the same situation the salivary glands cease to act. On the other hand the thought of savory food has been known to cause the saliva to issue in a jet from the sides of the mouth.

512. *Reserve Glands.*—Some glands also act only on particular occasions, as in the case of a broken bone, or cut in the flesh, when the appropriate vessels set themselves at work to repair the injury.

513. *Secretion after Death.*—Certain secretions are continued for a time after the death of the individual. Thus it has been observed that the hair and nails grow considerably after death, provided the disease was a rapid one, so that the system was not reduced by loss or degeneracy of the blood and nervous system. It is also related that in dissecting the poison apparatus of a rattle-snake, the poison was secreted so

Give the minute anatomy of the glands. Describe their ducts. Mention their various colors. 510. What is the use of the glands? Do the secretions exist ready formed in the blood? 511. What is the effect of the feelings upon secretion? Give an example. 512. What is said of reserve glands? 513. What is said of secretions continuing some time after death? Give an example.

fast that it was necessary to dry it off occasionally during the dissection.

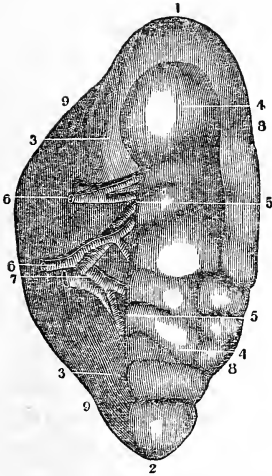
514. *Vicarious Secretion.*—Another curious phenomenon connected with this subject is vicarious secretion, where one organ performs the whole or part of the office of another. This is often seen in the function of the lungs and liver, where one imperfectly performing its office, is aided by the other. This vicarious secretion is still more apparent between the liver and skin. For in the disease known as Jaundice, where some obstruction is offered to the passage or secretion of the bile, it is poured out by the skin, coloring it deeply yellow, and in some instances it has been known to stain the linen, which is worn next the skin, perceptibly yellow.

515. *Ductless Glands.*—In connection with this subject it is proper to mention a class of organs known as Ductless Glands, or bodies which have the form and general structure of glands, but no duct or outlet, and form no secretion, as do the true glands. These are the Spleen, the Thymus and Thyroid Glands, and the Supra Renal Bodies. Of these only the former will be described here, since the latter are most perfectly developed during the earliest, or fetal stage of existence.

516. *The Spleen.*—The Spleen measures in different individuals from four to six inches in its longest diameter, and is situated under the left extremity of the stomach. (Fig. 282, p. 293.) It is of a reddish blue color, convex on its external, and concave on its internal surface. It is very abundantly supplied with blood-vessels, and consequently vascular or spongy in its structure. (Fig. 283, p. 293.) Upon a close inspection it is found to be made up of corpuscles from one third to one sixth of a line in diameter, each of which is composed of nucleated cells about $\frac{1}{5000}$ th of an inch in diameter. (Fig. 284, p. 293.)

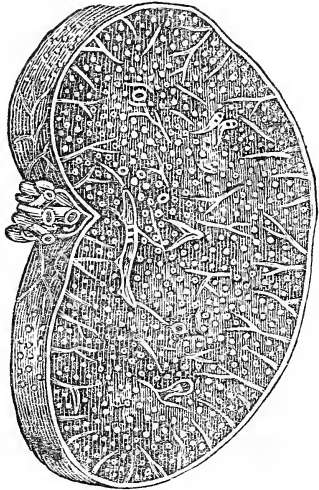
514. State the principle of vicarious secretion. What remarkable facts in this connection about jaundice? 515. Describe the ductless glands. What are their names? At what period of life are they the most fully developed? 516. Describe the spleen.

FIG. 282.



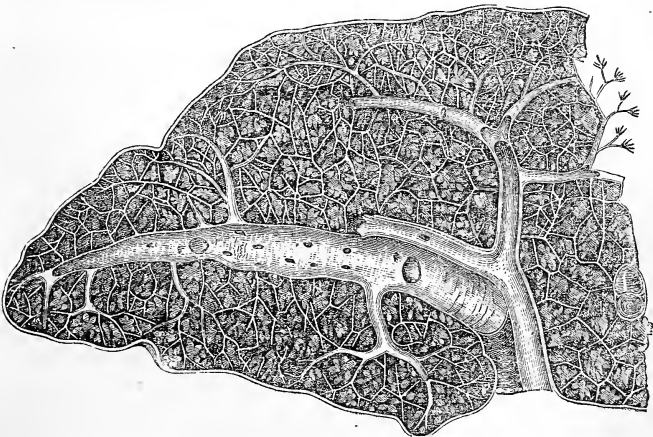
Shows the Internal Face of the Spleen where it touches the Stomach. 1, Superior Extremity. 2, Inferior Extremity. 3, Posterior Part of the Concave Face. 4, Anterior Part of the same. 5, Fissure of the Spleen. 6, Splenic Artery. 7, Splenic Vein. 8, 8, Anterior Edge of the Spleen. 9, 9, Its Posterior Edge.

Fig. 283.



Section of the Spleen.

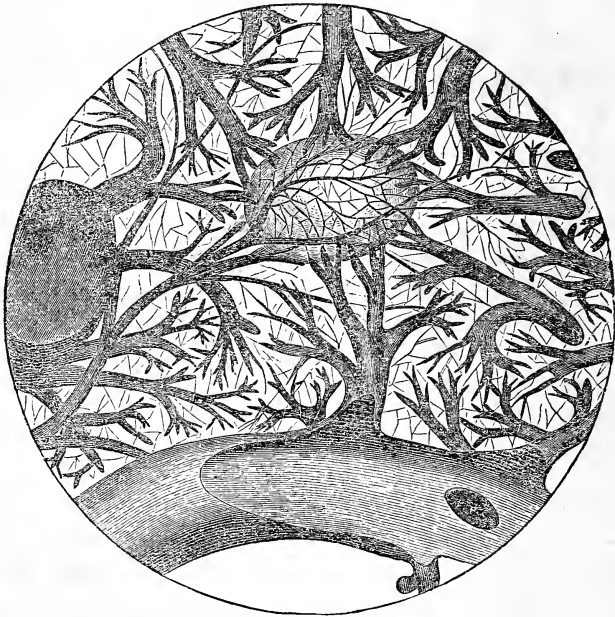
FIG. 284.



Section of the Spleen magnified.

517. Function of this Organ.—Produces and Destroys the Red Blood Corpuseles.—As already stated there is no duct or outlet to this organ, or evidence of any secretion out-

FIG. 285.



Small Portion of the Spleen very highly magnified, showing two corpuseles and the minute Blood-Vessels.

ward. But the idea has occurred to physiologists, though with no positive proof as yet, that a kind of secretion is produced by the spleen which is poured directly into the blood, and consequently there is no necessity for any outlet. And again experiments have been carried so far as to give plausibility to the idea, that this organ is designed to *produce blood corpuseles*, and at the same time use up those that are

517. Of what use is the spleen? What is said of it as an organ for producing blood corpuseles?

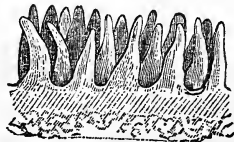
no longer of service to the body. Certain it is that no other organ in the body has as yet been discovered which subserves this purpose, and equally certain that in cases, where large wounds are to be healed, and in certain other conditions of the body, the white corpuscles are greatly increased in number.

518. *The Skin*.—Among those organs whose offices are those of absorption and secretion, the *Skin* finds a prominent place.

519. *Made up of Three Membranes*.—This is a membrane simple in its general aspect, but under the microscope it is found to be composed of no less than three distinct layers: the *Epidermis*, *Basement Membrane*, and *Corium*. It covers every part of the body, except the portion immediately surrounding the various orifices, and those portions of the extremities covered by the nails. It is highly elastic, as may be seen by the gaping of a long gash, and possesses a certain amount of contractility, owing to some muscular fibers contained in it.

520. *Papillæ; their Size*.—Upon several portions of the body the skin is roughened by small protuberances, either arranged in a circular form, or in rows, which are supplied with one or more loops of nerves. These are termed *Papillæ*, and are found most abundantly in the extremities, and especially upon the palms of the hand and soles of the foot. They vary in height from $\frac{1}{3}$ rd to $\frac{1}{2}$ d of a line, being of different lengths in different parts of the body.

FIG. 286.

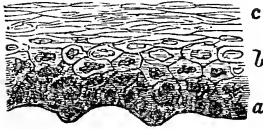


Papillæ from Palm of the Hand, magnified thirty-five times.

519. Of what three membranes is the skin made up? State their general properties. 520. What are the papillæ? Where are they found in the greatest numbers? State their size.

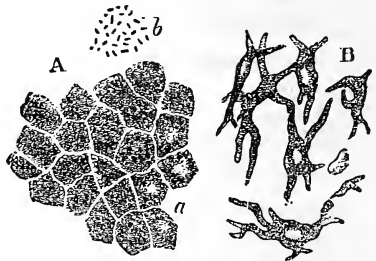
521. Epidermis or Cuticle; Has no Vitality.—Pigment Cells.—Composition of Pigment-Cells.—The outer layer of the skin is called the Cuticle or Epidermis, and bears the same relation to the true skin, that the outer bark of the tree does to the inner. In thickness it varies considerably in the different parts of the body. It is $\frac{1}{100}$ th of an inch thick on the chin, cheeks and brows, and $\frac{1}{6}$ th to $\frac{1}{9}$ th of an inch thick on the soles of the foot. It is merely a layer of albumen—

FIG. 287.



Vertical Section of Epidermis from a Negro. *a*, Deep Cells loaded with Pigment. *b*, Cells more elevated and somewhat flattened. *c*, Scaly Cells at the Surface.

FIG. 288.



Highly magnified Pigment-Cells. *A*, Scales of the Epidermis filled with Pigment Cells which are seen separate at *b*. *B*, Pigment Cells from the Choroid Coat of the Eye.

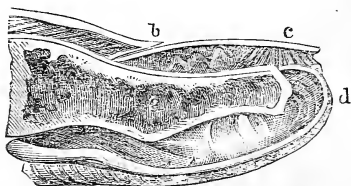
the same substance as the white of an egg—and is secreted by the true skin, in the form of scales, which are closely compacted together, and it is in this form that they are detached from the body by washing and friction. In some cases, however, it is detached in large patches, so that after certain skin diseases have run their career, the whole epidermis of the hand with the nails adherent may be removed in the manner of a glove. The epidermis contains no blood-vessels or nerves, and consequently no vitality, it being merely a secretion which hardens into a semi-transparent membrane. A part of the cells of the true skin, however, instead of secreting the epidermis, produce what are termed the Pigment

521. Describe the epidermis. To what does it correspond in the tree? State its thickness and chemical composition. What vessels and what cells does it contain? Where are the pigment cells shown?

Cells, which give color to the skin. These cells are best exhibited in the eye where the pigmentum nigrum (black paint) is secreted, and are of the same kind with those in the epidermis. They are oval or rounded granules, measuring $\frac{1}{500000}$ th of an inch in diameter, and one quarter of this in thickness, sometimes presenting a polygonal or stellate form. They have nearly the same composition as the coloring matter of the cuttle-fish, which contains a much larger proportion of carbon than is contained in most organic substances, namely $58\frac{1}{2}$ parts in hundred. The development of these cells depends mainly upon exposure to the sun's light. Hence we see that persons with a fair skin become of a darker hue, if exposed to the strong and direct light of the sun.

522. The Nails; Mode of Growth; Rate of Growth.—The Nails are composed of the same material as the epidermis, being merely an altered form of it. When their newest portions are examined with the microscope, they are found to be nucleated cells closely resembling those of the epidermis, Epithelium cells. The nail increases in length by successive additions to its root, which push it forward over the end of the finger, while at same time it receives additional layers from the skin beneath. The nails of the hands grow about two fifths of a line per week, while those of the foot require four times that period for the same amount of growth. The blood-vessels of the nails are very abundant, and are

FIG. 289.



Section of the Thumb. *c.* Last Done of the Thumb. *b.* Epidermis reflected on the Nail. *a.* Nail. *d.* Epidermis at the Point of the Thumb.

What is very remarkable about the chemical composition of this pigment? What does the development of these cells depend on? 522. Of what composition are the nails? Of what kind of cells are they? How fast do the nails of the hand grow?

situated just within the corium, into which the nail barely dips. And so numerous are these, and of so low a degree of vitality, that frequently the nails grow for a short distance after death. When the nails are badly injured, they are seldom perfectly regenerated, because of the injury done to the vessels and laminae. A rudimentary nail sometimes is found on the second joint, when the first is destroyed. Cases are also on record, where the nails have been shed and renewed periodically. The nails are thickest at their most convex portion, instead of their edges, and increase in thickness from the base to their free edge. They grow only so long as they are cut, and among the literary class of the Chinese, who never cut their nails, they are said to attain only a length of two inches. The time necessary for a nail to grow its whole length, varies from twelve to twenty weeks.

522 *a*. Basement Membrane of the Skin.—The middle layer of the skin is simply a basement membrane, and is in fact the mucous layer of the epidermis. It is, however, of little importance in the functions of the skin, and is believed to be a separate layer merely because, when it is immersed in a solution of potash in connection with the epidermis, the latter is dissolved, while the former is unchanged.

523. The Corium; its Composition; Nerves of the Corium.—The Corium or internal layer is the true skin, since it possesses the vitality and sensibility of this membrane, and contains all its vessels. It is made up of white and yellow fibrous tissue, the white predominating, except in those parts where occasional extension is required, where the yellow exists in larger proportion. The blood-vessels of the corium are very abundant, terminating in the minute tubes which supply the sudoriparous and sebaceous glands: the proof of the abundance of which we have in puncturing any part of

Why do the nails sometimes grow after death? Why do the nails seldom grow naturally after an injury? At what portion are the nails the thickest? 522 *a*. What is the middle layer of the skin? 523. Of what is the corium composed? What is said of the abundance of blood-vessels in the corium?

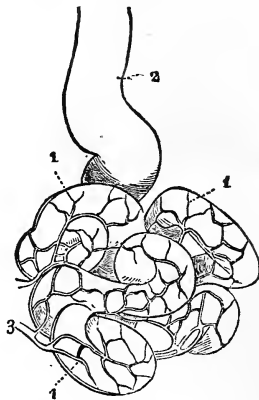
the skin with the finest needle, when a drop of blood is sure to follow. The nerves of sensation too are very abundant, as we know by the insertion of a pin into any part of the body, which invariably pains us, because we have wounded a nerve, and not an expanded surface, like a membrane.

524. *Sebaceous or Oil Glands.*—The Sebaceous Glands are small elongated sacs which are generally gathered in clusters about each of the hairs of the body, varying in number from four to twenty. They pour their secretion into the hair-canals near their orifices, and are most abundant in the parts of the body most exposed, as in the skin of the nose. Their secretion in most places resembles fat, although in the passage of the external ear a substance resembling wax (cerumen) is poured out.

524*a.* *Parasite in the Sebaceous Glands.*—It is a fact curious, if not at first sight revolting, that there is very constantly found in the outlets to many of the sebaceous glands a parasitic animal, as represented by the cut. (Fig. 291, p. 300.) The occurrence of this animal in almost every individual has led one anatomist to call it a “denizen” of the human body.

525. *Sweat Glands.*—Length of Sweat Tube in the Human Body.—The Sudoriparous or Sweat Glands essen-

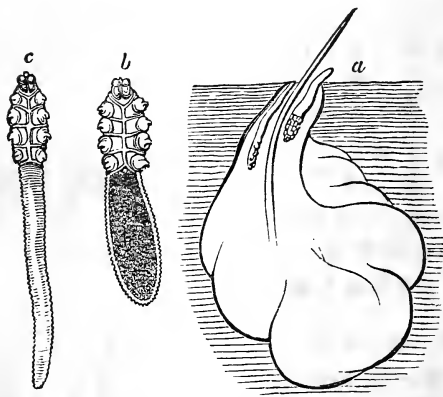
FIG. 290.



A View of the Cerumen Gland formed by the Contorted Tubes. 1, 1, The Tubes. 2, The Excretory Duct. 3, The Vessels supplying it.

What of the nerves in the corium? 524. What are the sebaceous glands? Where are they the most abundant? What is their secretion? 524*a.* What is said of the parasite in the skin?

FIG. 291.

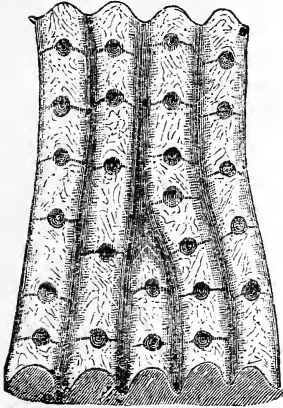


Parasites of the Sebaceous Glands. *a*. Two seen in their ordinary position at the Orifice of the Gland. *b*. Short Variety. *c*. Long Variety.

tially consist of long tubes convoluted and twisted upon themselves, (Fig. 293, p. 301), located just beneath the corium, several of which join to form an outlet, which passes through the epidermis in a spiral manner, so that as it opens externally, a valve is made preventing the entrance of substances from without, but allowing a ready exit to all substances to be discharged externally. The size of the gland proper is about $\frac{1}{70}$ th of an inch in diameter, and that of the tube is about $\frac{1}{400}$ th inch. The outlets of these tubes (Fig. 292, p. 301,) are called the pores of the skin, and are somewhat larger than the diameter of the tubes. The most remarkable fact, however, connected with these glands, is their immense number in the system. Each tube when straightened measures on an average one fourth of an inch in length, and by actual count there are at least 2,800 in every square inch of the body. (Fig. 293, p. 301.) Now the number of square inches in a man of ordinary height is 2,500, which would make the number of pores or openings about 7,000,000, or the whole length of

525. What is the general outline of the sweat glands? What is their size? How many on every square inch of the body? What is their aggregate length?

FIG. 292.

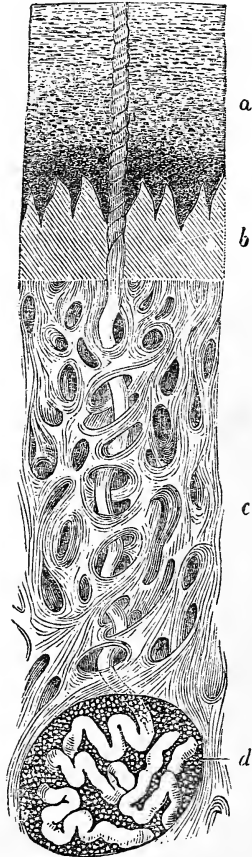


Skin of the Palm showing Ridges, Furrows, Cross Groves, and Pores, or Orifices of Sweat Ducts.

tube 145,853 feet, or 48,611 yards, or nearly 28 miles. Dalton says, 153,000 inches or two and a half miles.

526. The Perspiration.—Sensible and Insensible Perspiration.—The secretion poured out by these glands, is a transparent liquid of an acid reaction, and of a saltish taste, commonly known as sweat or perspiration. This is produced in two forms, known as sensible and insensible perspiration, which is escaping from the body in one of these forms constantly during health, the sensible being given off whenever excretion is so great as to leave moisture upon the skin.

FIG. 293.

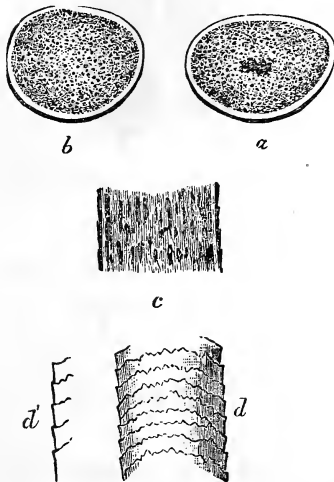


Vertical Section of the Sole of the Foot. a. Epidermis. b. Papillary Structure. c. Cutis. d. Sweat Gland magnified forty diameters.

527. Amount of Watery Vapor Discharged from the Body.—The amount of fluid which is lost from the body both by the skin and lungs, is about eighteen grains per minute, eleven by the skin and seven by the lungs. This amount, however, varies exceedingly with the state of the health and the dryness or moisture of the air, which, as already mentioned, regulates the temperature of the system.

528. The Hair.—The hair is distributed over nearly every portion of the human frame, and presents differences according to age, sex, race, or individual peculiarities. In length, the hair is most fully developed on the heads of females, sometimes equaling the length of the body, while in male beards it seldom reaches to the waist. The coarsest hair is also found on women.

FIG. 294.



Sections of Human Hair. *a, b*, Transverse Sections showing the Cortical (or external) and Medullary (or internal) Surface. *c, d*, Longitudinal Sections of Hair. *d*, Shows the overlapping of the Epidermic Scales of which hair is composed.

the true skin, as is seen in Fig. 295, p. 303. Just beneath the epidermis one or more glands are situated which empty their

529. Size of the Hair—Oil Glands.—In diameter the hair varies from $\frac{1}{140}$ th to $\frac{1}{2000}$ th of an inch, and its section is always of an oval outline, but never circular. Nor is the hair of a uniform diameter, but it is spindle-shaped almost always, and terminates in a point. At its base it expands into a bulb which is lodged in a sac in

527. What is the amount of watery fluid discharged from the body? 528. What is said of the distribution of the hair? How long has the hair been known to grow? 529. What is the diameter of the hair? What is the shape of it? What glands empty their contents upon the base of each hair?

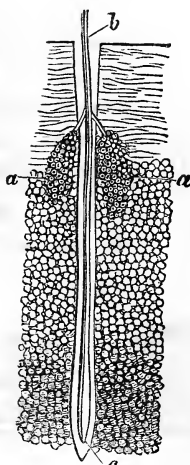
contents into the same pore in which the hair itself is located. This secretion is an oil which keeps the hair in a smooth and moist state.

530. Their Number.—The number of the hairs varies with the color and portion of the body. In one case there were found on the same surface 147 black hairs, 162 brown, and 182 blonde. On a surface one fourth of an inch square the same author found on the scalp 293 hairs and on the chin 39.

531. Their Distribution and Direction.—They are implanted either singly or in twos or threes, or even four or five together, and their direction is rarely perpendicular to the skin, being, in a natural state, downwards. They may, however, be changed in their direction by persevering efforts, as is sometimes seen by the brushing of the hair away from the forehead.

532. Chemical Composition—Durability.—They differ from most tissues of the body by containing ten per cent. of sulphur. This, together with the fact that they contain a large per cent. of nitrogen, accounts for the unpleasant odor given off while burning. They resist decomposition better than most of the tissues. Those of Egyptian mummies remain quite unchanged. And it is owing to their durability that they are used as relics of departed friends.

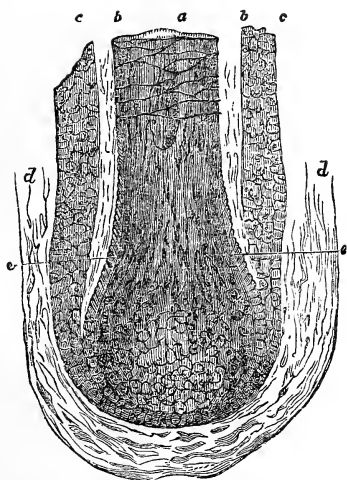
FIG. 295.



Layer from Scalp. *a*, Oil Glands. *b*, Hair *c*, Follicle.

530. What is said of the number of hairs on the body? 531. How are they distributed, and what direction do they take? 532. How do they differ from most other tissues in chemical composition? How durable is hair?

FIG. 296.



Highly Magnified Root of Hair. *a*, Shaft of Hair. *b, c*, Epidermic Sheath of Hair. *d*, Dermic, or External Sheath of Hair. *e*, Epidermic Scales.

granules and air cavities which give the color to the hair. The medullary portion constitutes the central part of the hair (usually from one third to one fifth its diameter), and is made up of cells varying in diameter from $\frac{1}{50000}$ th to $\frac{1}{60000}$ th of an inch in diameter.

533 *a*. Color.—The color of the hair is thought by some to be owing to the iron contained in it, since it is said that there is the most of this metal in the darkest hair.

533 *b*. Physical Properties.—Hair is so elastic that it will stretch without breaking to nearly one third more than its original length. A single hair of the head will support six ounces without breaking. It readily absorbs moisture, and is dry and brittle or moist and soft, according as the skin or atmosphere is dry or moist. The beard is abundantly

533. Constitution.—In constitution the hair consists of three distinct portions, an epidermis or outer portion, a fibrous, and a medullary portion. The epidermis is arranged in the form of ring-like scales, which overlap each other like the shingles of a house, and is about $\frac{1}{50000}$ th of an inch thick (Fig. 294, *d*). Hence we see the reason why we can brush the hair in only one direction. The fibrous portion makes up the principal bulk of the hair, and is composed of longitudinal

cells, which contain paint

533. What three portions is each hair constituted of? What makes the principal part of each hair? 533 *a*. What is it possible that the color of the hair is owing to? 533 *b*. What is the strength of the hair?

supplied with blood-vessels, as is seen by the cut.

533 c. Rate of Growth.—In one set of experiments the hair has been found to grow seven lines per month. Frequent shaving greatly increases its growth. It also grows faster by day than by night, and in summer than in winter.

FIG. 297.



A small portion of the Follicle of a Hair of the Beard, with the Arteries supplying it—very highly Magnified. 1, Its Follicle. 2, Its Pulp. 3, The Trunk of the Hair without the Follicle. 4, 4, Two Arteries going to the Base of the Follicle. 5, 5, Their Distribution. 6, 6, The Reticulated Tissue of the Follicle.

FUNCTIONS OF THE SKIN.

534. The Skin a Covering.—The skin is the natural covering of the body of man, and he is not furnished with any further and more complete covering, as is the case with many of the lower animals, since he is endowed with an ability to devise means of covering better suited to his condition than one of hair, wool, or feathers.

535. Use of the Epidermis—To Protect the Nerves.—The epidermis is of use to protect the corium and its vessels. Without this covering many of our sensations acquired through the skin would be very painful. The contact of the softest Eider down with the exposed nervous filaments would impart the acutest pain, and the rays of the noonday sun would inflict the keenest torture. The body could not endure the lightest clothing, and even our motion through the air would

533 c. What is said of the rate of growth of the hair? 534. What is said of the skin as a covering? 535. What is said of the epidermis as a source of protection to the delicate nerves of touch?

be a source of misery. But these delicate nerves are protected by an insensible membrane, which, though hard, elastic, and a very perfect guard of these faithful sentinels, permits all the necessary impressions to pass through them. The epidermis also guards the most delicate parts in a careful manner, by thickening its substance over the ends of the fingers, and in all places where sensation is most acute. It is also speedily renewed where friction or accident removes it, as on the palms of the hands and soles of the feet.

536. To prevent Absorption.—Another important use of the epidermis is to prevent undue absorption. For the lymphatics only penetrate the corium, and cease at the under surface of the epidermis. Consequently but very little fluid can enter these vessels unless the epidermis is removed or saturated with fluid. Were it not for this protection, almost every liquid substance brought in contact with the surface of the body would at once be introduced into the general circulation, thus exposing the system to serious danger by absorbing poisonous matter.

537. To Prevent Excessive Perspiration.—Danger from an opposite direction is also warded off by the impenetrability of the epidermis. Were it not for the tortuous direction which the outlets of the sweat glands take as they empty themselves upon the surface of the body, an excessive amount of water would be set free, and thus greatly reduce the system. But owing to this arrangement of sweat ducts, it is only when the system is very much stimulated that any considerable amount of water can be discharged by sweating. Were not this the case, the body would often be reduced to a low state from the loss of the watery portion of the blood, as is sometimes seen in excessive sweating.

538. Use of the Corium—Contains the Blood-Vessels

536. What is the use of the epidermis to prevent undue absorption? 537. How does the epidermis prevent undue perspiration? What harm would result from excessive sweating?

and Nerves—Amount of Waste Escaping from the Skin.—In the corium, or internal layer of the skin, resides the vitality. Here the arteries terminate in the capillaries and the nerves double upon themselves, producing the highest sensibility to external impressions. So that when any function of the skin is spoken of, reference is usually made to this inner layer. And we see that the skin is not only useful as a protection and covering to the body, but is of great value as an excretory apparatus. And in this office the skin is peculiarly valuable, since it removes a great amount of matter from the system that the lungs cannot remove. The actual amount of waste matter escaping daily from the skin is given variously by different writers. All, however, make out an average of from thirty to forty ounces, or if condensed to water, about two pints. A proof that the vapor of water escapes in the form of insensible perspiration is had by placing the dry hand upon a cold glass or polished metallic substance, when moisture in a few seconds condenses on the surface.

539. Uses of the Oil Glands—Renders the Hair Soft—Softens the Skin—Protects the Eye—Guards the Membrana Tympani.—The function of the sebaceous, or oil glands of the skin seems to be the secretion of substances protective to the skin. These are mainly oily products, and are given off at the roots of the hair, so as to give it flexibility, that by its stiffness it may not irritate the skin. The oil tubes are most abundant on those parts of the body which are most exposed, and especially the face and neck. The design of the secretion seems to be to give flexibility to the skin, to prevent the heat and air from drying it so that it would crack in many places, and also to lubricate it when brought into contact with foreign substances, as is the case so frequently with the hands. The oil of the skin also prevents moisture from adhering to it, and thus its functions can be more perfectly carried on, and

538. Where lies the vitality of the skin? What other use than a protection is the skin? How much waste matter escapes daily from the skin? How many pints? 539. What is the use of the oil glands? How does it affect the hair? What value does it impart to the skin?

it will not retain all dust which chances to fall upon it. At the flexions of the joints, and all those places where two surfaces of the skin are frequently brought in contact, this oily secretion is abundantly poured out, in order that there may be as little friction as possible between the opposing surfaces. Upon the edges of the eyelids is situated a row of glands which pour out their secretion in such a manner as to retain the tears—the lubricating fluid of the eye—when produced in their ordinary quantity; but when in excess, as in weeping, they run over their boundaries, and flow down the cheek. The use of these glands may be well appreciated in some diseases of the eye, where the tears constantly run down upon the cheek, producing irritating sores.

In the passages of the ears we find the same glands, although their secretion is of a somewhat different character. Here it is a clammy, viscid substance, of a yellowish color, and from its appearance it is called the wax of the ear. Its service is to prevent dust and foreign substances generally from gaining access to the internal ear, where they would injure the sense of hearing.

HYGIENIC INFERENCES.

540.—1. Great Value of this Membrane in the Animal Economy.—From the complicated structure of the skin, we see that this membrane is of great service in the animal economy. It stands next in importance to the lungs as an excretory organ, and if its functions are interrupted the whole system very soon feels the disturbance.

541.—2. Its Health Requires Cleanliness.—The skin must be kept clean to secure the proper functions of the perspiratory glands. This not only implies the necessity of fre-

How does it affect the skin at the joints? Of what service is it to the eye? Of what to the ear? 540. State the relative value of the skin in the animal economy. 541. Why is cleanliness essential for the health of the skin?

quently washing the whole surface of the skin, but also the frequent change of the bed-clothes, under-clothes, etc. And it should be a fixed rule with every one to change the linen and under-garments both night and morning; that is, the under-garment worn during the day should not be worn at night, and the reverse.

542.—3. Must be Kept at a Uniform Temperature.—We also learn that the skin should be kept at a uniform temperature, and up to its normal standard. It therefore needs proper clothing, not so much in the coldest weather—for then our feelings will impel us to do it—but at the changes of temperature so common and so great in our climate in spring and autumn, for then we are too apt to neglect it because we feel no especial inconvenience, and yet at these times there is more danger of disease from a want of proper clothing than at any other season of the year. We seldom injure ourselves by too much clothing, because we can easily throw off superfluous garments, but often do it by too small an amount of protection. An important rule for every one is, when going abroad even a short distance from home, to carry with him an over garment when exposed to evening air.

543.—4. Must Come in Contact with the Air.—The skin imbibes oxygen from the air, and hence it is important that air be brought in contact with this membrane. The clothing should be worn so loosely that a thin layer of air will be in contact with nearly every part of the skin.

544.—5. Needs Friction.—Frequent and thorough dry friction applied to every part of the skin greatly promotes the health, not only of this membrane, but of the whole body. So smooth are the clothes we generally wear next the skin, that but little stimulus is received by them, and hence a thorough

542. What is necessary for the temperature of the skin, especially for changes in weather? What is said of an over-coat as a constant traveling companion? 543. Why should the skin have air in contact with it? 544. What is the use of friction to the skin?

rubbing of the whole body every night and morning will aid greatly in this matter.

545.—6. Injurious Effects of Moisture upon the Skin.—Moisture if applied to the skin for a considerable length of time interrupts its functions, and accordingly we infer that wet or damp clothing should not be allowed to remain on the body any longer than is absolutely necessary. If, however, dry clothing cannot be procured immediately, the body should be kept in vigorous action of some kind until the clothes can be changed. This inference is of equal application, whether the whole of the body be wet, or only a portion of it, as the feet.

546.—7. Service of a Daily Cold Water Bath.—We infer again that a daily cold water bath is of great service for all students and sedentary persons who are in health. Not only is it desirable on account of cleanliness, but a serviceable shock is thus imparted to the nervous system. It, however, should be taken as speedily as possible, the essential thing desired being, that pure water should be spread over the whole surface of the body, and after it that the skin should be speedily and vigorously wiped dry. The secondary effect, however, the stimulus imparted to the nervous system by the shock, is by no means an unimportant issue to be gained.

COMPARATIVE DERMATOLOGY.

547. Covering of Mammals.—The skin of mammals very closely resembles that of man, with the exception of the epidermis and its horny appendages, which are usually covered by hair. The fat tissue, too, just beneath the skin, is often developed in a surprising degree, and the corium in many instances is very thick. Some have horny scales, and others long plates.

545. What are the injurious effects of too much moisture applied to the skin? 546. What is said of a daily bath, and what regulations concerning it? 547. What is said of the covering of mammals?

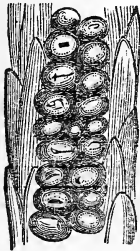
548. *Callosities*.—In many of the rodent or gnawing animals, the carnivora and camels, the epidermis about the joints becomes very thick, making callosities or pads for the support and protection of the parts exposed.

549. *Epidermic Scales*.—True Epidermic Scales are found on the tails of many animals, such as the Beaver.

550. *Horn of Rhinoceros*.—The so-called horn of the Rhinoceros is nothing but a thickening of the epidermis until it assumes the form of a hollow cone.

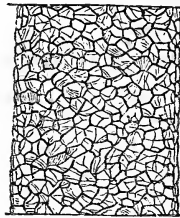
551. *Varieties of Hair*.—The hairs upon the external surface of mammals either present no greater irregularities

FIG. 298.



Hair of Sable.

FIG. 299.



Hair of Musk Deer.

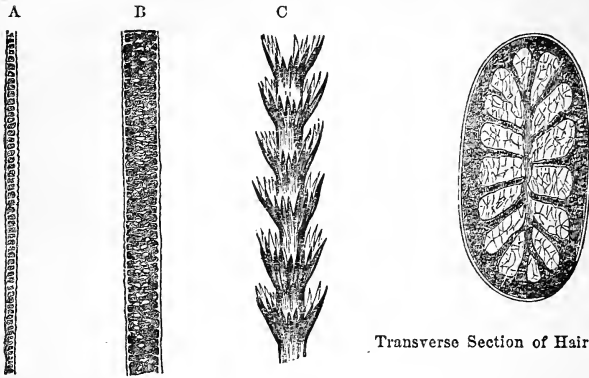
than do those of man, or they are slightly rough, like those of the Squirrel, or knotty, as in the Bear, or furnished with pointed processes, like the teeth of a saw, in other animals. Some of these peculiarities are exhibited in the adjoining cuts. The spines of the Porcupine and Hedgehog differ from hairs only that they contain the same materials in a more condensed form.

552. *Glands of the Skin*.—Cutaneous and sebaceous glands are present in most mammals very abundantly. The

549. To which membrane of the skin do the callosities of camels, etc., belong? 549. Where are epidermic scales found? 550. What is the horn of the rhinoceros? 551. What are the varieties of hair in different animals? 552. What is said of glands of the skin

FIG. 300.

FIG. 301.



Transverse Section of Hair of Pecari.

A. B. Hairs of Squirrel. C. Hair of Indian Bat.

latter secrete an unctuous fluid, which is usually of a strong smell.

553. *Skin of Birds.*—The Skin of Birds is thin and destitute of cutaneous glands, except one at the tail, which is generally present. The whole body is covered by feathers, except certain parts of the head, legs, and feet. There it becomes very much thickened, forming callosities, wattles and combs, in which, beside the cellular tissue, are found the elastic and erectile tissues, as well as red and blue cells of coloring matter. Upon the toes and feet are found plates and scales of horny tissue.

554. *Feathers of Birds.*—The Feathers of Birds are made up of the Quill and Vane: the former giving it attachment to the body, and the latter forming its expanded surface. The Vane is made up of a small number of laminæ or plates, which both form a light and firmly resisting medium to the air, and serve to retain the heat within the body. When perfectly formed the laminæ are furnished with a hooklet at their free extremities, by which they are attached to each other,

553. What is the thickness of the skin of birds compared with that of mammals? What are the wattles and combs? 554. What two parts are feathers made up of? Why are the laminæ furnished with a barb at each extremity? What is the design of their overlapping each other?

thus making each feather an impenetrable plane surface. The feathers also overlap one another to a considerable degree, and as they thus contain air, and are themselves non-conductors, they afford the most perfect protection to the body against the cold.

555. Skin of Amphibia.—The naked Amphibia, such as the Frogs, have a smooth slippery skin, which is continually being cast off in patches or shreds. This skin surrounds the solid parts of the body very loosely, and spaces for lymphatic vessels are found beneath. It is always composed of several layers of fibres which lie at right angles with each other.

556. Scales of Serpents.—Upon some serpents, scales are found which overlap one another, like the shingles of a house, as is also the case with fishes. Scales with tubercular spines are met with on some reptiles, and in some instances, as those of Crocodiles and Tortoises, they contain bony matter, and coalesce with the bones of the skeleton.

557. Exuviation of Serpents.—Many Serpents cast their skin several times during the year, either by piecemeal, or by drawing off the whole at once. One species of Tortoise does the same thing, as well as several Lizards. This is an analogous function to the moulting of birds, and shedding of the coat in mammals. This generally takes place in Spring, but frequently upon a change of weather several times in the year. At each period, when this is effected by the Rattle-Snake, a new segment is said to be added to the tail, which seems quite probable, since the rattle is merely a condensed portion of the epidermis.

558. Scales of Fishes.—Classification of Fishes by their Scales.—Fishes have an Epidermis which is sometimes covered with scales, and sometimes not, though always lubricated most thoroughly by a copious mucous secretion. The

555. What is said of the skin of frogs? 556. Do serpents ever have scales? 557. What is the exuviation of serpents? When does this take place? What peculiarity in the rattle-snake? 558. How are the scales of fishes arranged?

scales are sometimes disposed in an imbricated manner upon the body, and are not situated in the epidermis, "but really in the skin, and included by it." The scales contain both phosphate and carbonate of lime as a rule. Their shapes are various, though Professor Agassiz, the best living authority on fishes, has grouped all bony fishes under four orders, dependent mainly upon the form of the scale. First, the Placoidians, including such fishes as the Sharks and Rays, where the scales are either large and covered with bony tubercles, or simply with small enameled scales. Second, the Ganoidians, including the Sturgeon and bony Pike, which have angular bony plates coated with a thick layer of enamel. Third, the Ctenoidians, such as the Perch, which have hard scales jagged on the outer edges, like the teeth of a comb. Fourth, Cycloidians. These have soft and circular scales with simple margins. In this order are found the Herring and Salmon. Sometimes the scales are provided with a hook-like process, which overlaps and fastens itself into a depression in the scale beneath.

559. Tegument of Articulata.—Horny Case of Insects.—The Tegumentary envelop of the sub-kingdom Articulata has already been described under Comparative Osteology, since the skin of many of this sub-kingdom, especially the crustacea and insects, is in reality the only skeleton these animals have. Insects have a covering sometimes leathery and soft, and sometimes horny and solid, which contains a peculiar proximate (chemical) principle known as Chitine.

560. Mantle of Molluscs.—In Molluscous animals, a dermis, which is a muscular skin, envelops all the viscera, and hence is called the cloak or mantle, which secretes the hard calcareous covering known as the shell. Generally the shell is external to the mantle, as in the Clam and Oyster,

What are the four orders dependent upon the form of the scale? Who is the author of this arrangement? Give examples of each. 559. What is the covering of the articulata? What is peculiar about its chemical composition? 560. Describe the outside covering of molluscs.

but often, as in the *Cypræa* or Cowry, the mantle extends over the shell.

561. Radiates.—With the exception of the hard external skeleton of these animals already described, their proper skin is mostly thin and soft, allowing of great flexibility and sometimes of great expansion and contraction.

The Protozoa have a very delicate, cutaneous envelope, sometimes smooth and sometimes covered with cilia.

Effect of Fright on Hair.—A Sepoy of the Bengal Army, brought as a prisoner for examination before the British officers, was terribly affrighted, trembled like a leaf, and was almost stupified with fear. Such was the shock upon his brain that his hair, from a glossy jet black, became gray within the space of an hour, the subject being only twenty-four years of age.

Also a boy, let down from a high cliff on the coast of Scotland to get eggs of sea-birds. He, in defending himself from the birds with the sword, struck the rope by which he was suspended, and cut off every strand but one. When drawn up his hair was white.

Maria Antoinette experienced a change in the color of her hair during one night's excessive fear.

CHAPTER SEVENTH.

THE INSTRUMENTS OF ANIMATION.—NEUROLOGY, OR THE BRAIN AND NERVES.

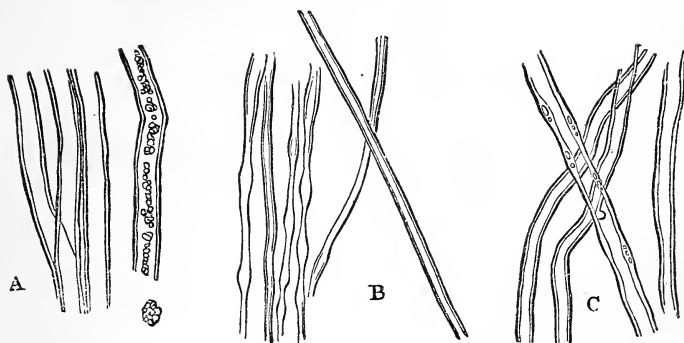
DEFINITIONS AND DESCRIPTIONS.

562. Main Features of the Nervous System.—We now come to an organization which is very complicated in structure, some of whose functions are the most obscure of any in the body. It is called the Nervous System: and the different grades in the animal kingdom are established by placing those having the most complicated nervous system highest on the scale. Man having the largest brain in proportion to the rest of his body, and possessed of the greatest relative amount of nerves, is therefore placed at the head of the animal kingdom.

563. Microscopic Structure.—Tubular Portion.—Diameter of the Tubes.—In microscopic structure the nervous tissue presents two essential elements: the fibrous or tubular, which is mainly found in the nerve trunks, and the cellular or vesicular, existing more abundantly in the ganglia or nerve centers. In the former the tubes are the largest in the trunks of the nerves, and gradually diminish as they approach the brain, varying in size from the $\frac{1}{2000}$ th to the $\frac{1}{24000}$ th of an inch, and sometimes existing even as large as the $\frac{1}{500}$ th of an inch. They are sometimes conical also, measuring at one end from $\frac{1}{2000}$ th of an inch to $\frac{1}{24000}$ th: the smallest end being found near the nerve trunks, and are sometimes called coarse

562. Give the leading features of the nervous system. 563. What are the two microscopic elements of nervous tissue? Give the size of the tubular portion.

FIG. 302.



Tubular Nerve Fibers.

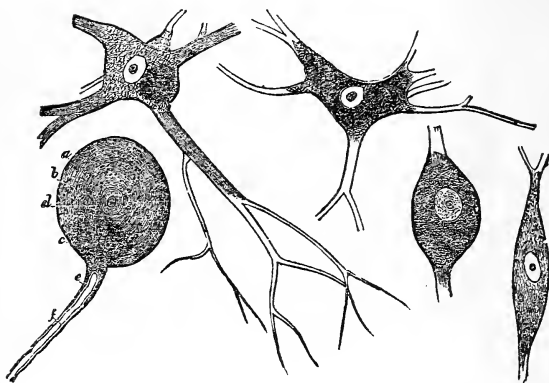
nerve fibers. These fibers have the appearance of a double tube, or a small tube within a larger one, and sometimes exhibit small nucleated cells within the two.

564. A closer examination shows an inner or grayish portion which is called the axis cylinder, and a white substance around this called the medullary matter, or substance of Schwann, and outside of the whole a membranous tube. (Fig. 302.) They are often called Fine Nerve Fibers. The sympathetic system, on the other hand, seems to be made up of tubes without this double structure, and when several of them are joined in a bundle, they present a grayish appearance. They are also of a much smaller size, varying mostly from $\frac{1}{150000}$ th to $\frac{1}{60000}$ th of an inch.

565. Vesicular Structure.—The vesicular substance is composed of cells or vesicles, which present very curious forms, being somewhat stellate or caudate. The central portion is globular, consisting of a nucleated cell, which sends off processes in different directions, as seen in the annexed Figure 303. Their diameter is exceedingly variable, meas-

What is the structure of the sympathetic system? 564. What still more minute structure can be detected by the microscope? 565. Describe the vesicular structure. Give the diameter of the cells.

FIG. 303.



Vesicular Nerve Corpuscles. *a.* Cell Wall. *b.* Cell Contents. *c.* Pigment. *d.* Nucleus. *e.* Prolongation forming Sheath of the fiber. *f.* Nerve Fiber, magnified 350 diameter.

uring from $\frac{1}{200}$ th to $\frac{1}{600}$ th of an inch. These are found in the ganglia and the substance of the brain.

566. Divisions of the Nervous System.—The nervous system consists of a central portion contained within the cavity of the skull and the spinal column, and a great number of white threads ramifying through every part of the body. The physical condition upon which the activity of the nervous system depends, is the supply of arterial blood.

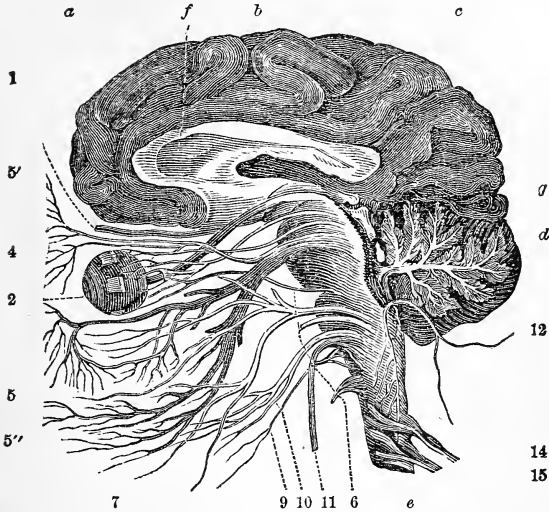
567. Cerebrum.—If we examine the parts within the skull, (Fig. 304, p. 319,) we shall find the greater mass of it to be of a spheroidal form, divided nearly into two halves by a deep fissure or cleft, and its surface is singularly roughened by elevations and depressions called anfractuositities.

568. This mass is the Cerebrum or Great Brain, and the two divisions are called its hemispheres. (Fig. 307, p. 321.)

569. In man the average weight of the brain is fifty-four ounces, in females forty-five; the maximum being sixty-four,

566. What principal divisions does the nervous system consist of? 567. Describe the cerebrum. 569. What is the average weight of the brain?

FIG. 304.



Vertical Section of the Brain, Cerebellum, Pons Varolii, and Medulla Oblongata. *a*, Anterior Lobe of the Brain. *b*, Middle Lobe. *c*, Posterior Lobe. *d*, Cerebellum. *e*, Medulla Spinalis. *f*, Section of the Corpus Callosum. The Lateral Ventricles of the Brain are situated on either side of the Corpus Callosum, which assists in forming their Upper Wall. *g*, Optic Lobes: 1, Olfactory Nerves. 2, The Eyeball, from which may be traced the Optic Nerve as far as the Optic Thalami or Lobes. Close to this is the Nerve of the Third Pair. 4, The Fourth Pair, distributed, like the Third, to the Muscles of the Eyes. 5, Superior Maxillary Branch of the Fifth Pair. 5', Ophthalmic Branch of the same Pair of Nerves. 5'', Inferior Maxillary Branch of the same Pair of Nerves. 6, Sixth Pair, proceeding to the Abducentes Muscle. 7, Facial Nerve:—under the origin of this nerve may be seen a portion of the Acoustic 9, Nerve called Glosso-Pharyngeal. 10, Pneumogastric Nerve; close to it is 12, the Spinal Accessory. These three Nerves, the Glosso-Pharyngeal, Pneumogastric, and Spinal Accessory, are by some reckoned as one pair. 11, The Ninth Pair of some, and the Eleventh of others, called also Hypoglossal. 14 and 15, Cervical Nerves.

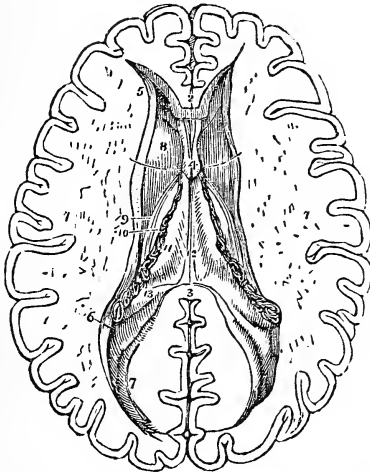
and the minimum twenty; the average capacity of the crania of Germans and Anglo-Saxons is ninety cubic inches. Daniel Webster's cranium contained 122 cubic inches.

570. Cerebellum.—The Cerebrum, by a band of thick fibers, is connected with another body, of a pear shape, attached to it by its base, called the Lesser Brain or Cerebellum. (Fig. 306, p. 320.) This has about one eighth of the

State the average capacity of Anglo-Saxon crania, and also that of Daniel Webster.
570. Describe the cerebellum.

weight of the Cerebrum, and lies directly behind and beneath it.

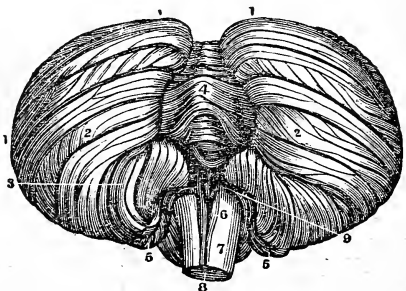
FIG. 305.



The Lateral Ventricles of the Cerebrum. 1, 1, The two Hemispheres cut down to a level with the Corpus Callosum, so as to show the Centrum Ovale Majus. The Surface is studded with the small Puncta Vasculosa. 2, A small portion of the Anterior Extremity of the Corpus Callosum. 3, Its Posterior Boundary; the intermediate portion, forming the Roof of the Lateral Ventricles, has been removed so as to completely expose these Cavities. 4, A part of the Septum Lucidum, showing a space between its Layers which is the Fifth Ventricle. 5, The Anterior Cornu of one Side. 6, The commencement of the Middle Cornu. 7, The Posterior Cornu. 8, The Corpus Striatum of one Ventricle. 9, The Tænia Striata. 10, A small part of the Thalamus Opticus. 11, The Plexus Choroïdes. 12, The Fornix. 13, The commencement of the Hippocampus Major in the Middle Cornu. The Rounded Oblong Body in the Posterior Cornu of the Lateral Ventricle, directly behind the Figure 13, is the Hippocampus Minor. A Bristle is seen in the Foramen of Munro.

pus Major in the Middle Cornu. The Rounded Oblong Body in the Posterior Cornu of the Lateral Ventricle, directly behind the Figure 13, is the Hippocampus Minor. A Bristle is seen in the Foramen of Munro.

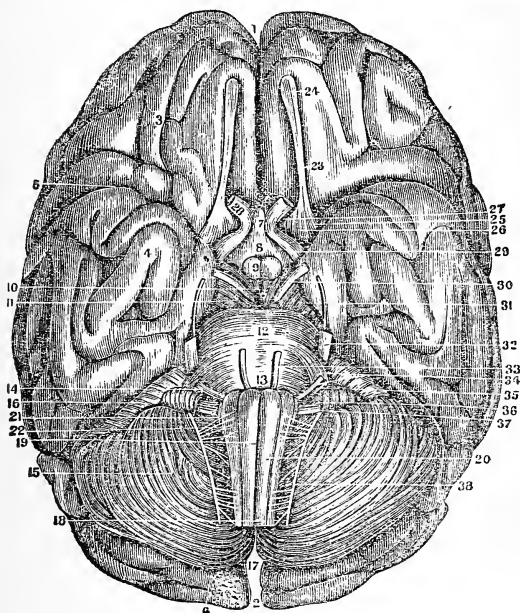
FIG. 306.



A View of the Interior Surface of the Cerebellum and a Portion of the Medulla Oblongata. 1, 1, The Circumference of the Cerebellum. 2, 2, The two Hemispheres of the Cerebellum. 3, Lobulus Amygdaloïdes. 4, The Vermis Inferior. 5, Lobulus Nervi Pneumogastrici. 6, The Calamus Scriptorius. 7, Its Point. 8, Section of the Medulla Oblongata. 9, Points to the Origin of the Pneumogastric Nerve.

571. Cerebral Ganglia.—Also lying directly upon the base of the brain, are found several distinct enlargements or

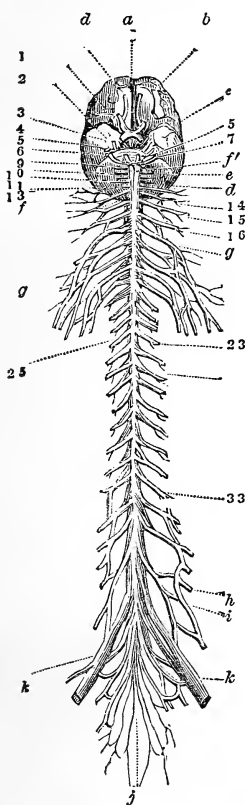
FIG. 307.



A View of the Base of the Cerebrum and Cerebellum, together with their Nerves. 1, Anterior Extremity of the Fissure of the Hemispheres of the Brain. 2, Posterior Extremity of the same Fissure. 3, The Anterior Lobes of the Cerebrum. 4, Its Middle Lobe. 5, The Fissure of Sylvius. 6, The Posterior Lobe of the Cerebrum. 7, The Point of the Infundibulum. 8, Its Body. 9, The Corpora Albicantia. 10, Cinerities Matter. 11, The Crura Cerebri. 12, The Pons Varolii. 13, The Top of the Medulla Oblongata. 14, Posterior Prolongation of the Pons Varolii. 15, Middle of the Cerebellum. 16, Anterior Part of the Cerebellum. 17, Its Posterior Part and the Fissure of its Hemispheres. 18, Superior Part of the Medulla Spinalis. 19, Middle Fissure of the Medulla Oblongata. 20, The Corpus Pyramidale. 21, The Corpus Restiforme. 22, The Corpus Olivare. 23, The Olfactory Nerve. 24, Its Bulb. 25, Its External Root. 26, Its Middle Root. 27, Its Internal Root. 28, The Optic Nerve beyond the Chiasm. 29, The Optic Nerve before the Chiasm. 30, The Motor Oculi, or Third Pair of Nerves. 31, The Fourth Pair, or Pathetic Nerves. 32, The Fifth Pair, or Trigemini Nerves. 33, The Sixth Pair, or Motor Externus. 34, The Facial Nerve. 35, The Auditory—the two making the Seventh Pair. 36, 37, 38, The Eighth Pair of Nerves. (The Ninth Pair are not here seen.)

ganglia, the most important of which are the Thalami Optici, Corpora Striata, Olfactive Ganglia, and Tubercula Quadrigena.

FIG. 308.



572. Spinal Cord.—Upon the anterior portion of the Cerebellum, commences the Spinal Cord, the upper portion of which, situated within the skull, is about three inches in length and one in breadth, and is called the Medulla Oblongata.

573. Cerebro-Spinal Center.—These portions of the nervous system constitute what is known as the Cerebro-Spinal Axis or Center, and are all made up of two kinds of mat-

The Cerebro-Spinal Axis seen Anteriorly. The Nerves have been cut through at a short distance from their Origin or *central termination*. *a*, The Cerebrum. *b*, Anterior Lobe of the Left Hemisphere of the Brain. *c*, Middle Lobe. *d*, Posterior Lobe, almost concealed by the Cerebellum. *e*, The Cerebellum. *f*, The Medulla Oblongata or Bulb. 1, First, or Olfactory Pair of Nerves. 2, Second Pair, or Optic. 3, Third Pair, or Motores Oculorum. 4, Fourth Pair, or Pathetic. 5, The Facial, or Fifth Pair. 6, Sixth Pair, or Abducentes. 7, Nerves of the Seventh Pair, or Facial; also the Acoustic, or Portio Mollis, by some called the Auditory, and viewed as a division of the Seventh; others call them the Eighth Pair. 9, The Glosso-Pharyngeal Nerves, called the Ninth Pair by some, by others the Anterior Division of the Eighth Pair. 10, The Pneumogastric, by some included in the Eighth Pair, by others called the Tenth Pair. 11, Nerves of the Eleventh and Twelfth Pairs, the first being viewed by some as a Division of the Eighth Pair, and called Spinal Accessory; the latter, called by some the Ninth, by others the Twelfth, is

the Motor Nerve of the Tongue. 13, Nerves of the Thirteenth Pair, or Sub-Occipital. 14, 15, 16, The First, Second, and Third Pairs of Cervical Nerves. *g*, Cervical Nerves forming the Brachial Plexus. 25, One of the Pairs of Nerves of the Dorsal Portion of the Spinal Marrow. 33, One of the Pairs of Lumbar Nerves. *h*, Lumbar and Sacral Nerves forming the Plexus whence come the Nerves of the Lower Extremities. *i* and *j*, Termination of the Spinal Marrow, called *Cauda Equina*. *k*, Great Sciatic Nerve proceeding to the Lower Extremities.

572. What is the medulla oblongata? 573. What two kinds of matter does a slicing of the brain show, and how is the gray and white matter disposed?

branes envelop the brain, although to the unassisted eye they appear as one. They are of great importance in the economy of the brain, and are often the seat of severe disease. The outer one is called the Dura Mater, that covers both the brain and spinal cord, and is attached firmly to the bones which it covers. It has the same composition as the ligaments of the body—white fibrous tissue—and consequently is very tough, being the firmest of the three membranes.

576. Arachnoid Membrane.—The Arachnoid Membrane lies directly beneath the dura mater, and receives its name from the Greek word signifying spider's web.

577. Pia Mater.—Closely beneath it is the Pia Mater, which lies directly upon the surface of the brain, and dips into all the cavities or convolutions on its surface. This membrane is especially serviceable in the nourishment of the brain, and receives the arteries which enter at the anterior and posterior part of the skull. Its nerves are branches of the sympathetic system.

578. Surface of the Brain.—The surface of the brain is very uneven, being covered with convolutions or tortuous ridges and corresponding depressions, the design of which is not as yet well known, though probably merely to procure a greater amount of surface, and they do not correspond to the irregularities on the surface of the skull from which phrenologists profess to judge of character.

579. Ventricles of the Brain.—Within the brain are several cavities called ventricles, of which the special use has not been determined. (Fig. 305, p. 320.) It is a curious fact, however, that a post mortem examination of the brain of inebriates frequently discovers these cavities to be partially filled with alcohol.

580. Division of the Nerves.—All the nerves that pro-

575. How many membranes enveloping the brain? Describe the dura mater. 576. Describe the arachnoid membrane. 577. Describe the pia mater. What are its nerves? 578. What is the condition of the surface of the brain? 579. What are the cavities in the brain called? 580. How are all the nerves given off from the brain and spinal cord?

ceed from the cerebro-spinal axis are given off in pairs on opposite sides of the median line of the body. They are divided into two sets; those which are given off from the great brain, little brain, and medulla oblongata, being called *cranial nerves*, and those from the spinal cord, *spinal nerves*.

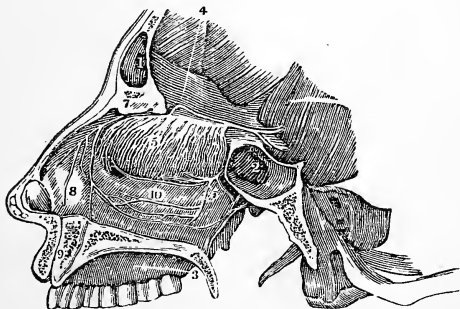
581. *Cranial Nerves*.—Many of the cranial nerves, and all of the spinal nerves, arise by two roots, and soon form a small protuberance, which is called a Ganglion or knot, in which the fibers are confusedly mixed together, after which they proceed in the same sheath to their destination.

582. Of the cranial nerves there are twelve pairs, named as follows :

First pair.	Olfactory.	Seventh pair.	Facial.
Second "	Optic.	Eighth "	Auditory.
Third "	Motores Oculorum.	Ninth "	Glosso-Pharyngeal.
Fourth "	Trochleares.	Tenth "	Par Vagi.
Fifth "	Trifacial.	Eleventh "	Spinal Accessory.
Sixth "	Abducentes.	Twelfth "	Lingual.

583. *Olfactory*.—The *olfactory nerves* arise from the an-

FIG. 310.

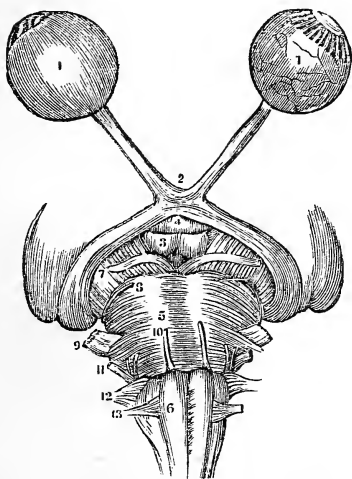


A View of the First Pair, or Olfactory, with the Nasal Branches of the Fifth. 1, Frontal Sinus. 2, Sphenoidal Sinus. 3, Hard Palate. 4, Bulb of the Olfactory Nerve. 5, Branches of the Olfactory on the Superior and Middle Turbinated Bones. 6, Sphenopalatine Nerves from the Second of the Fifth. 7, Internal Nasal Nerve from the First of the Fifth. 8, Branches of Seventh, to Schneiderian Membrane. 9, Ganglion of Clôquet in the *foramen incisivum*. 10, Anastomosis on the Inferior Turbinated Bone of the Branches of the Fifth Pair.

What are the two principal groups of nerves? 581. How many roots do most of the nerves have? 582. How many pairs of cranial nerves, and what are their names?

terior portion of the base of the brain, and are distributed upon the mucous membrane of the nostrils; especially that part of it which is spread out upon the turbinated bones.

FIG. 311.



A View of the Second Pair or Optic, and the Origin of Seven other Pairs. 1, 1, Globo of the Eye. The one on the left hand is perfect, but that on the right has the Sclerotic and Choroid removed to show the Retina. 2, The Chiasm of the Optic Nerves. 3, The Corpora Albicantia. 4, The Infundibulum. 5, The Pons Varolii. 6, The Medulla Oblongata. The figure is on the Right Corpus Pyramidale. 7, The Third Pair, Motores Oculi. 8, Fourth Pair, Pathetici. 9, Fifth Pair, Trigemini. 10, Sixth Pair, Abducentes. 11, Seventh Pair, Auditory and Facial. 12, Eighth Pair, Pneumogastric, Spinal Accessory, and Glosso-Pharyngeal. 13, Ninth Pair, Hypoglossal.

584. Optic.—The *optic nerves* arise at a point behind that where the olfactory nerves are given off, and about one inch from this point come together and form a ganglion; after this they are again separated and proceed to the posterior portion of each eye-ball, where they are expanded into a membrane, called the Retina. (Fig. 311.)

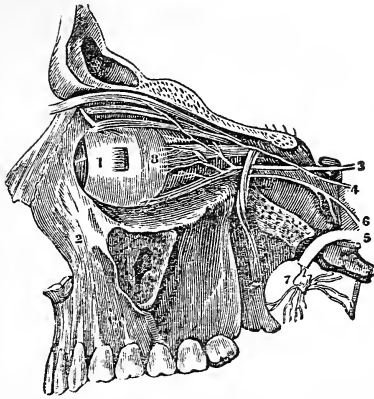
585. *Motores Oculorum*.—The *third pair* are also given off from the base of the brain near to the pons varolii, and are sent to a part of the muscles of the eye.

586. *Trochleares*.—The *trochleares* have nearly the same origin as the last-mentioned pair, and are distributed to the superior oblique muscles of each eye. (Fig. 312.)

587. *Trifacial*.—The *fifth pair*, or *trifacial*, is the largest of the cranial nerves. It is analogous to the spinal nerves in

583. Give the anatomy of the olfactory nerves. 584. Describe the optic nerves. 585. Describe the motores oculorum. 586. Give the anatomy of the fourth pair. 587. Describe the trifacial.

FIG. 312.



A View of the Third, Fourth, and Sixth Pairs of Nerves. 1, Ball of the Eye, the Rectus Externus Muscle being cut and hanging down from its origin. 2, The Superior Maxilla. 3, The Third Pair, or Motor Oculi, distributed to all the Muscles of the Eye except the Superior Oblique and External Rectus. 4, The Fourth Pair, or Patheticus, going to the Superior Oblique Muscle. 5, One of the Branches of the Fifth. 6, The Sixth Pair, or Motor Externus, distributed to the External Rectus Muscle. 7, Spheno-Palatino Ganglion and Branches. 8, Ciliary Nerves from the Lenticular Ganglion, the short Root of which is seen to connect it with the Third Pair,

A View of the Distribution of the Trifacial, or Fifth Pair. 1, Orbit. 2, Antrum of Highmore. 3, Tongue. 4, Lower Maxilla. 5, Root of Fifth Pair, forming the Ganglion of Casser. 6, First Branch, Ophthalmic. 7, Second Branch, Superior Maxillary. 8, Third Branch, Inferior Maxillary. 9, Frontal Branch, dividing into External and Internal Frontal at 14. 10, Lachrymal branch, dividing before entering the Lachrymal Gland. 11, Nasal Branch. Just under the figure is the long Root of the Lenticular or Ciliary Ganglion, and a few of the Ciliary Nerves. 12, Internal Nasal, disappearing through the Anterior Ethmoidal Foramen. 13, External Nasal. 14, External and Internal Frontal. 15, Infra-Orbital Nerve. 16, Posterior Dental Branches. 17, Middle Dental Branch. 18, Anterior Dental Nerve. 19, Terminating Branches of Infra-Orbital, called Labial and Palpebral. 20, Subcutaneous Male, or Orbital Branch. 21, Pterygoid or Recurrent, from Meckel's Ganglion. 22, Five Anterior Branches of Third of Fifth, being Nerves of Motion, and called Masseter, Temporal, Pterygoid, and Buccal, 23, Lingual Branch joined at an acute angle by the Chorda Tympani. 24, Inferior Dental Nerve terminating in 25, Mental Branches. 26, Superficial Temporal Nerve. 27, Auricular Branches. 28, Mylo-hyoid Branch.

FIG. 313.

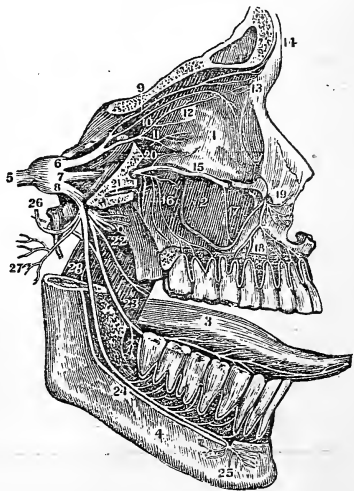
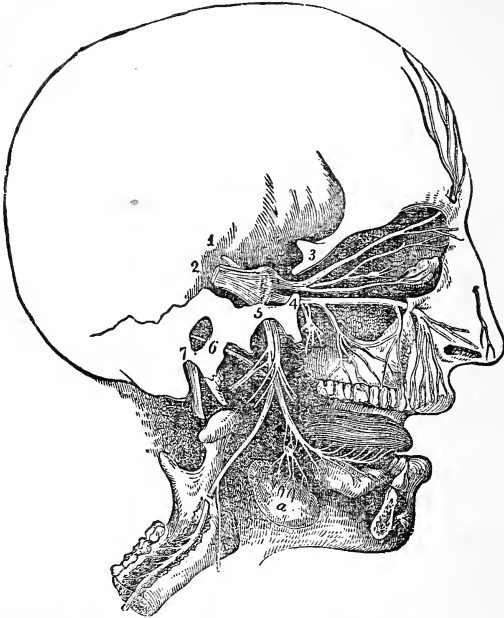


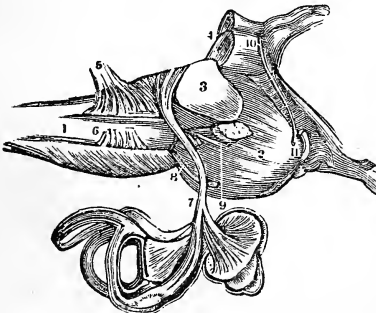
FIG. 314.



Distribution of the Fifth Pair of Nerves. *a*, Submaxillary Gland. 1, Small Root of the Fifth Nerve. 2, Casserian Ganglion. 3, Ophthalmic Nerve. 4, Upper Maxillary Nerve. 5, Lower Maxillary Nerve. 6, Chorda Tympani. 7, Facial Nerve.

that each nerve arises by two roots, and afterwards, before distribution, forms the Casserian ganglion. This ganglion is separated into three branches: the ophthalmic, which supplies

FIG. 315.



the region of the eye and nose; the superior maxillary, supplying different parts of the face from the temporal muscle to the

A View of the Origin and Distribution of the Portio Mollis of the Seventh Pair, or Auditory Nerve. 1, The Medulla Oblongata. 2, The Pons Varolii. 3, 4, The Crura Cerebelli of the Right Side. 5, Eighth Pair. 6, Ninth Pair. 7, The Auditory Nerve distributed to the Cochlea and Labyrinth. 8, The Sixth Pair. 9, The Portio Dura

of the Seventh Pair. 10, The Fourth Pair. 11, The Third Pair.

lips, including the upper teeth and the inferior maxillary, sending its branches to the tongue, cheeks, and anterior portion of the face.

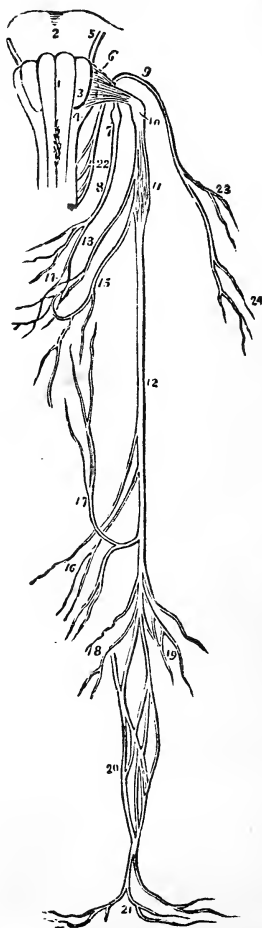
588. *Abducentes*.—The sixth pair, *abducentes*, are sent from the medulla oblongata to the external muscle of the eye.

589. *Facial*.—The *facial nerves* have their origin in common with the last pair. They join with some of the branches of the fifth pair, and distribute their filaments to some of the muscles of the face.

590. *Auditory*.—The *auditory nerves*, as their names imply, are sent to the ear. They enter the internal ear

Origin and Distribution of the Tenth Pair of Nerves. 1, 3, 4. The Medulla Oblongata. 1 Is the Corpus Pyramidale of one side. 3, The Corpus Oblivare. 4, The Corpus Restiforme. 2, The Pons Varolii. 5, The Facial Nerve. 6, The Origin of the Glosso-Pharyngeal Nerve. 7, The Ganglion of Andersch. 8, The Trunk of the Nerve. 9, The Spinal Accessory Nerve. 10, The Ganglion of the Pneumogastric Nerve. 11, Its Plexiform Ganglion. 12, Its Trunk. 13, Its Pharyngeal Branch forming the Pharyngeal Plexus (14), assisted by a Branch from the Glosso-Pharyngeal (8), and one from the Superior Laryngeal Nerve (15). 16, Cardiac Branches. 17, Recurrent Laryngeal Branch. 18, Anterior Pulmonary Branches. 19, Posterior Pulmonary Branches. 20, Esophageal Plexus. 21, Gastric Branches. 22, Origin of the Spinal Accessory Nerve. 23, Its Branches distributed to the Sterno-Mastoid Muscle. 24, Its Branches to the Trapezius Muscle.

FIG. 316.



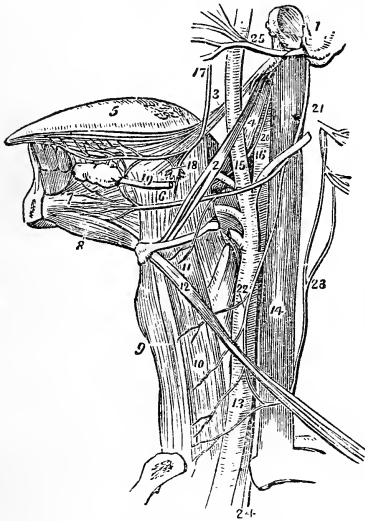
588. Describe the abducentes. 589. Describe the facial nerves. 590. Describe the auditory nerves.

after receiving fibers from the facial, and there divide into two branches, which are distributed in the irregular labyrinth of the ear.

591. Glosso-Pharyngeal.—The *glosso-pharyngeal* makes the ninth pair, and is sent to the mucous surface of the fauces, tongue, tonsils, and mucous glands of the mouth.

592. Par Vagi, or Pneumogastric.—The tenth pair, *par vagum*, spring from the medulla oblongata, and after giving branches to several of

FIG. 317.



of the cranial nerves, are distributed upon the heart, lungs, stomach, and nearly all the organs of the thorax and abdomen.

593. Spinal Accessory.—The *spinal accessory* takes its origin from the

The Anatomy of the side of the Neck, showing the Nerves of the Tongue. 1, A Fragment of the Temporal Bone containing the Meatus Auditorius Externus, Mastoid, and Styloid Process. 2, The Stylo-Hyoid Muscle. 3, The Stylo-Glossus. 4, The Stylo-Pharynx. 5, The Tongue. 6, The Hyo-Glossus Muscle; its two portions. 7, The Genio-Hyo-Glossus Muscle. 8, The Genio-Hyoideus; they both arise from the inner surface of the Symphysis of the Lower Jaw. 9, The Sterno-Hyoid Muscle. 10, The Sterno-Thyroid. 11, The Thyro-Hyoid, upon which the Thyro-Hyoidean Branch of the Hypoglossal Nerve is seen ramifying. 12, The Omo-Hyoid crossing the Common Carotid Artery (13), and Internal Jugular Vein (14). 15, The External Carotid giving off its Branches. 16, The Internal Carotid. 17, The Gustatory Nerve giving off a Branch to the Submaxillary Ganglion (18), and communicating a little further on with the Hypoglossal Nerve. 19, The Submaxillary, or Wharton's Duct, passing forwards to the Sublingual Gland. 20, The Glosso-Pharyngeal Nerve, passing in behind the Hyo-Glossus Muscle. 21, The Hypoglossal Nerve curving around the Occipital Artery. 22, The Descendens Noni Nerve, forming a Loop with (23) the Communicans Noni, which is seen to be arising by filaments from the Upper Cervical Nerves. 24, The Pneumogastric Nerve, emerging from between the Internal Jugular Vein and Common Carotid Artery, and entering the Chest. 25, The Facial Nerve, emerging from the Stylo-Mastoid Foramen, and crossing the External Carotid Artery.

24, The Pneumogastric Nerve, emerging from between the Internal Jugular Vein and Common Carotid Artery, and entering the Chest. 25, The Facial Nerve, emerging from the Stylo-Mastoid Foramen, and crossing the External Carotid Artery.

Describe the glosso-pharyngeal, par vagum, and spinal accessory.

upper part of the spinal column, and afterwards enters the cranium. After keeping company with the par vagum for a part of its course, it is distributed to some of the muscles upon the head and face.

594. *Lingual*.—The *lingual nerve* plunges its branches deeply into the fibers of the tongue, and communicates with a branch of the trifacial.

595. *Spinal Cord*.—The *spinal cord* is that portion of the cerebro-spinal axis contained within the channel made by the foramina, or openings of the vertebra. It extends from the medulla oblongata just at the base of the skull, to the second lumbar vertebra, and has an average diameter of half an inch. It has the general appearance of a flattened cord, but on a closer inspection it appears to be made up of two smaller cords, called the lateral cords, nearly separated by two clefts, called the anterior and posterior median fissures. This cord is not perfectly uniform in its size, but presents two enlargements, one at the point where the nerves are given off to the upper extremities, and the other near the lower end of the cord.

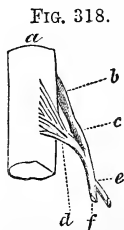


FIG. 318.
 Portion of the Spinal Cord, and Origin of one Pair of Nerves. *a*, Spinal Cord. *b*, Posterior Root. *c*, Ganglion. *d*, Anterior Root. *e*, Trunk formed by both. *f*, Branch.

596. *Microscopic Structure of the Spinal Cord*.—In anatomical structure we find the spinal cord and spinal nerves are made up of two kinds of nervous matter, the white and the gray, and also that each pair of these nerves arises by an anterior and a posterior root. The posterior root is made up of gray nervous tissue, and is called the sensitive root, since it gives the sense of feeling to the parts where it is distributed; the anterior root of white fibers is called the motor root, because it imparts motion to the different muscles of

594. Describe the lingual. 595. What is the spinal cord? How many fissures has the spinal cord? How many enlargements? 596. What is the microscopic structure of the spinal cord? Which is the sensitive and which the motor root?

the body. A ganglion is found upon the posterior root, just before it unites with the anterior.

597. Origin of the Spinal Nerves.—Between each of the vertebræ the spinal nerves are given off. These are made up of fasciculi, and each fasciculus of distinct fibers which somewhat resemble muscular fiber. They arise on each side of the cord by two roots, one given off from the anterior and the other from the posterior part of the lateral cords; the anterior root being the one that is designed to produce motion, and the posterior giving sensation to the parts on which it is distributed. These two roots unite as soon as they have fairly left the spinal cord, after which they proceed as a single nerve. (See Fig. 318.)

FIG. 319.

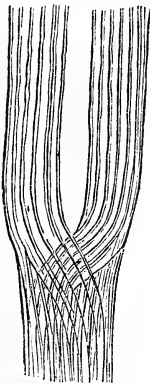


Diagram to show the Decussation (crossing from side to side) of Nerve Fibers in a Nerve.

Although there is to the naked eye a complete interlacement and an apparent loss of fiber, yet by the microscope these fibers can be distinctly traced through the whole mass, with the exception of a few which are interchanged for purposes to be described hereafter. After emerg-

598. Groups of Spinal Nerves.—These nerves are grouped together, and have the same name as the groups of vertebræ in which they are located.

8 Cervical.
12 Dorsal.

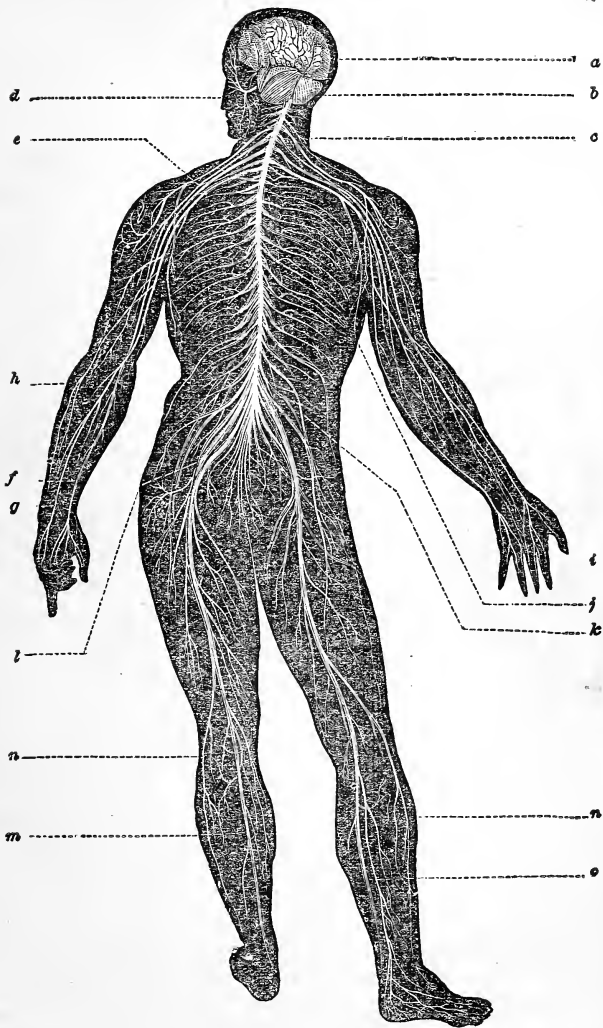
5 Lumbar.
6 Sacral.

The last nine are additional, or supplementary to the spinal cord, and not properly a portion of it. They are called the cauda equina.

599. Plexuses.—Most of these nerves are grouped together soon after leaving the spinal column, each group being called a plexus (from the Greek "to weave"), which is simply a net-work of

597. Give the origin of the spinal nerves. 598. State the groups of the spinal nerves. 599. Describe the nature of the plexuses.

FIG. 320.



Nervous System.

a, Brain. *b*, Little Brain. *c*, Spinal Marrow. *d*, Facial Nerve. *e*, Brachial Plexus, caused by the union of several Nerves coming from the Spinal Marrow. *f*, Median Nerve. *g*, Cubital Nerve. *h*, Internal Cutaneous Nerve of the Arm. *i*, Radial and Musculo-Cutaneous Nerve of the Arm. *j*, Intercostal Nerves. *k*, Femoral Plexus. *l*, Sciatic Plexus. *m*, Tibial Nerve. *n*, External Peroneal Nerve; *o*, External Saphenous Nerve.

ing from the plexuses, the nerves proceed to their destination and receive names, many of which are the same as the arteries which they accompany.

600. Cervical Plexus — Brachial Plexus — Lumbar Plexus — Sacral Plexus.—The cervical plexus is made up of the four upper cervical nerves, and the brachial plexus of the

FIG. 321.

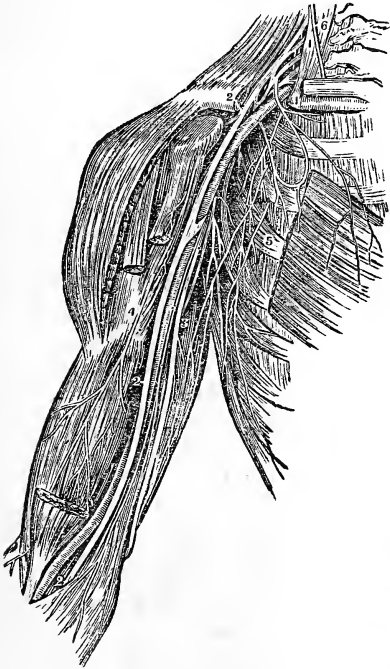


FIG. 322.



A View of the Brachial Plexus of Nerves and Branches of Arm. 1, 1, The Scalenus Anticus Muscle, in front of which are the Roots of the Plexus. 2, 2, The Median Nerve. 3, The Ulnar Nerve. 4, The Branch to the Biceps Muscle. 5, The Nerves of Wrisberg. 6, The Phrenic Nerve from the Third and Fourth Cervical.

Nerves of Front of Fore-Arm. 1, Median Nerve. 2, Anterior Branch of Musculo-Spiral or Radial Nerve. 3, Ulnar Nerve. 4, Division of Median Nerve in the Palm to the

Thumb, First, Second, and Radial Side of Third Finger. 5, Division of Ulnar Nerve to Ulnar Side of Third and both Sides of Fourth Finger.

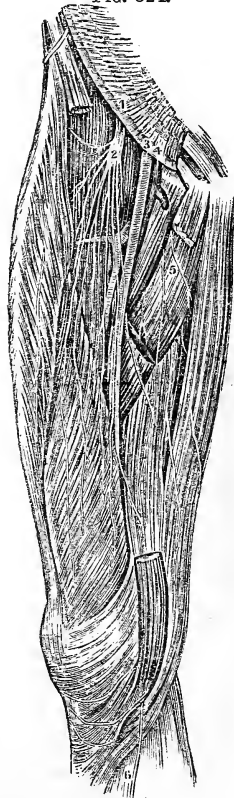
four lower cervical and upper dorsal nerves, and they give off their branches to the upper part of the body. The lumbar plexus is made up of the last dorsal nerve and the five lumbar nerves; and the sacral plexus of a branch of the last lumbar and the upper sacral nerves. These supply the portions of the body below the loins, and the superficial parts of the body between the loins and upper part of the chest.

FIG. 323.



A View of the Branches of the Ischiatic Plexus to the Hip and Back of the Thigh. 1, 1, Posterior Sacral Nerves. 2, Nervi Glutei. 3, The Internal Pudic Nerve (Nervus Pudendalis Longus Superior). 4, The Lesser Ischiatic Nerve, giving off the Perineal Cutaneous (Pudendalis Longus Inferior), and 5, The Ramus Femoralis Cutaneous Posterior. The reference to the Great Ischiatic has been omitted. It is seen to the right of 3.

FIG. 324.



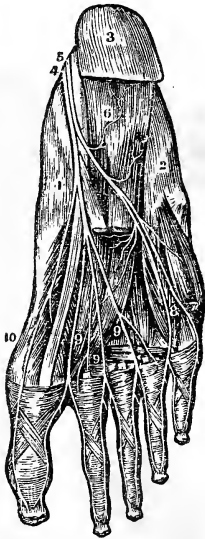
A View of the Anterior Crural Nerve and Branches. 1, Place of emergence of the Nerve under Poupart's Ligament. 2, Division of the Nerve into Branches. 3, Femoral Artery. 4, Femoral Vein. 5, Branches of Obturator Nerve. 6, Nervus Saphenus.

Describe the lumbar and sacral plexus.

601. Direction of the Nerves.—The largest and most important nerves follow the same general direction as the larger blood-vessels, and generally are in close proximity to them.

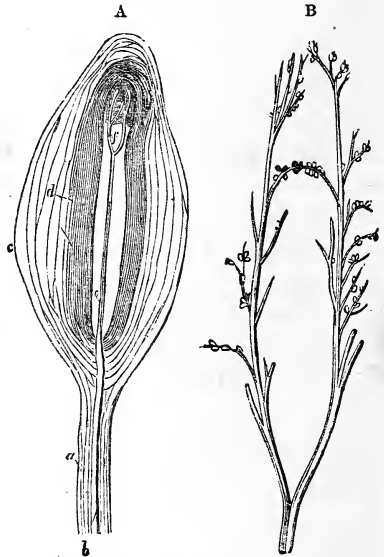
602. Motor Nerves—Mode of Termination—Pacinian Corpuscles.—The nerve fibers which go from the anterior columns of the spinal cord terminate in the fleshy portions of the muscles, because they are the motor nerves, or those ex-

FIG. 325.



A View of the Termination of the Posterior Tibial Nerve in the Sole of the Foot. 1, Inside of the Foot. 2, Outer Side. 3, Heel. 4, Internal Plantar Nerve. 5, External Plantar Nerve. 6, Branch to Flexor Brevis. 7, Branch to Outside of Little Toe. 8, Branch to Space between Fourth and Fifth Toes. 9, 9, 9, Digital Branches to remaining Spaces. 10, Branch to Internal Side of Great Toe.

FIG. 326



Pacinian Corpuscles. A, Single Corpuscle highly Magnified. *a*, Its Peduncle. *b*, Its Nerve Fiber. *c*, Outer Layers, and *d*, Inner Layers of the Capsule. *e*, Nerve Fibers, and *f*, Its Subdivision and Termination. B, Portion of Digital Nerves, with Pacinian Corpuscles attached.

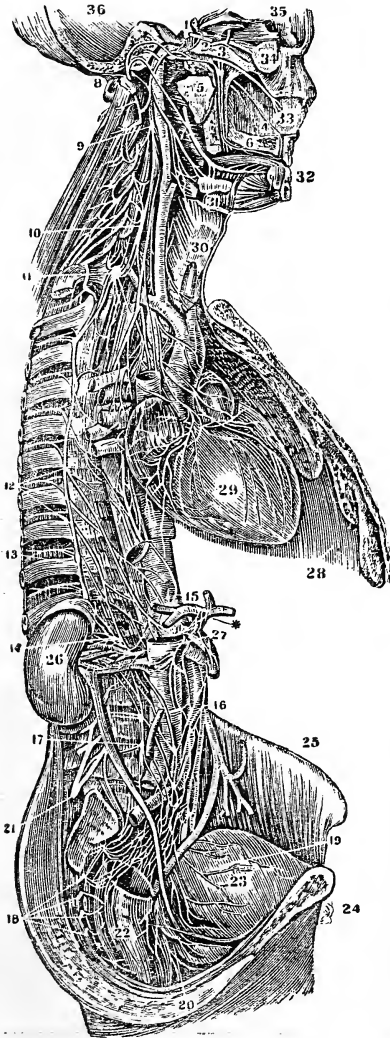
601. Give the general direction of the nerves through the body. 602. Where do the motor nerves terminate?

citing motion. Those from the posterior columns spread through the surface of the body, giving sensation to the skin. The mode, however, in which they terminate is not always the same. As far as at present is known, they seldom terminate in a free or single extremity, but in loops, returning into themselves, or joining with other fibers. And it is an anatomical fact that the nerve tubes do not anastomose one with the other, as is the case among the blood-vessels; but each tube discharges its own duty, and not that of another under any circumstances. In the skin of the hand and foot they terminate in minute oval bodies from the $\frac{1}{15}$ th to the $\frac{1}{10}$ th of an inch in length, and from one twenty-sixth to one twentieth of an inch in breadth, called Pacinian Corpuscles (from Pacini, their discoverer), and are attached to the branches and extremities of the nerves very much in the same manner as some kinds of fruit are attached to their boughs. (Fig. 326.) Of these, there are about six hundred in the hand and a somewhat smaller number in the foot. They are composed of connective or areolar tissue in from twenty to sixty bands, with interspaces containing a serous fluid, and are attached to their nervous twig by a rounded peduncle. The function of these bodies is entirely unknown.

603. Sympathetic System — Its Size — Connection with Spinal Nerves—Destination of its Branches.— Besides the cerebro-spinal center, there is another organization of nervous tissue which is called the Sympathetic Nerve, or Ganglionic System, and is to be regarded as an appendage of the spinal nerves. It is of very limited size, consisting of mere reddish threads of nervous matter and oval bodies called ganglia, never so large as peas. These ganglia and nerves extend along each side of the spinal column from

State the manner in which they terminate. Give a description of the Pacinian corpuscles. 603. What is said of the structure of the sympathetic system?

FIG. 327.



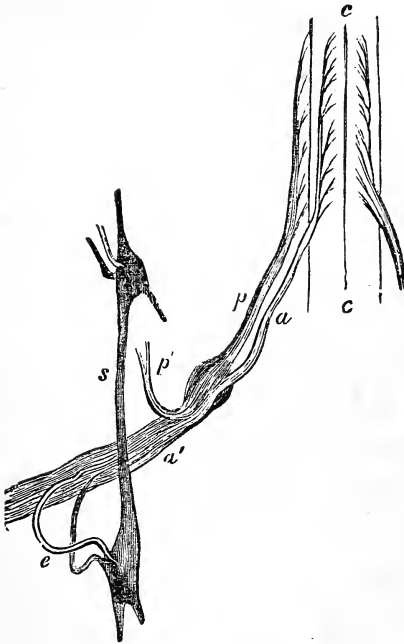
the atlas to the coccyx, communicating with all the spinal nerves by two small fibers (see Fig. 328), and giving branches to all the internal organs and viscera. Branches and ganglia are also found between the bones of the cranium and the face. The branches which are given off to the internal organs accompany the arteries to the same, forming a net-work

Great Sympathetic Nerve. 1, Plexus on the Carotid Artery in the Carotid Foramen. 2, Sixth Nerve (Motor Externus). 3, First Branch of the Fifth, or Ophthalmic Nerve. 4, A Branch on the Septum Narium going to the Incisive Foramen. 5, Recurrent Branch, or Vidian Nerve dividing into the Carotid and Petrosal Branches. 6, Posterior Palatine Branches. 7, Lingual Nerve joined by the Chorda Tympani. 8, Portio Dura of the Seventh Pair. 9, Superior Cervical Ganglion. 10, Middle Cervical Ganglion. 11, Inferior Cervical Ganglion. 12, Roots of the Great Splanchnic Nerve arising from the Dorsal Ganglia. 13, Lesser Splanchnic Nerve. 14, Renal Plexus. 15, Solar Plexus. 16, Mesenteric Plexus. 17, Lumbar Ganglia. 18, Sacral Ganglia. 19, Vesical Plexus. 20, Rectal Plexus. 21, Lumbar Plexus (Cerebro-Spinal). 22, Rectum. 23, Bladder. 24, Pubis. 25, Crest of the Ilium. 26, Kidney. 27, Aorta. 28, Diaphragm. 29, Heart. 30, Larynx. 31, Submaxillary Gland. 32, Incisor Teeth. 33, Nasal Sep-

tum. 34, Globe of the Eye. 35, 36, Cavity of the Cranium.

Where does it give its branches?

FIG. 328.



Roots of a Dorsal Spinal Nerve, and its union with the Sympathetic.

c, c, Anterior Fissure of the Spinal Cord. *a*, Anterior Root. *p*, Posterior Root, with its Ganglion. *a'*, Anterior Branch. *p'*, Posterior Branch. *s*, Sympathetic. *e*, Its Double Junction with the Anterior Branch of the Spinal Nerve by a White and Gray Filament.

of communication around the vessels. And as all the internal organs, especially those called vital, are supplied with this nerve, and not directly from the cerebro-spinal center, it is hence called a nerve of organic life.

604. Sympathetic Ganglia.—Each of these ganglia may be considered as a nervous center sending forth strands in three directions; 1st, to join the spinal nerves in their distribution; 2d, to the spinal cord itself; 3d, to the next sympathetic ganglion above.

605. **Groups of Sympathetic Ganglia.**—These ganglia are grouped together according to the locality, to which their branches are distributed. Thus we have the Cranial ganglia, Cervical ganglia, Thoracic ganglia, Lumbar ganglia, and Sacral ganglia. Besides these there are several large plexuses which have received distinct names, although a great number of small ones have not received any names. Of the most important ones we may name the Pharyngeal, in the immediate vicinity of the Pharynx, the Cardiac lying upon the heart, and the Solar, between the liver and stomach, or, as is more commonly known, the pit of the stomach.

606. **The Solar Plexus.**—The Solar Plexus seems to be, as its name implies, a sun or center for nervous power to the intestines, since branches from this plexus accompany the arteries to the vital organs, where they subdivide again and again, and enter their coats and substance.

FUNCTIONS OF THE NERVOUS SYSTEM

607. The functions of the Nervous System are the most important and delicate of any in the body. 1. The Brain affords a seat and center for life and intellect. 2. The nerves are inlets for all the senses to the sensorium or seat of sensation. 3. They are the medium of all the movements of the body, voluntary and involuntary. 4. They establish and maintain a sympathy between all the parts of the body, and equalize all the vital forces. 5. They preside over the involuntary functions, such as the circulation of the blood, digestion, respiration, and reflex actions.

608. **Intellect and Will located in the Brain.**—**Voluntary Movements dependent on the Brain.**—**The whole Brain not essential.**—**The Intellect and**

605. How are the sympathetic ganglia grouped together? What is said of the sympathetic plexuses? 606. Describe the solar plexus. 607. What are the five principal functions of the nervous system?

Will evidently reside in the brain (cerebrum), and require that this organ should be in a healthy state, since, if any disease affects its whole substance, their power is destroyed. Voluntary muscular movements depend on a sound and healthy brain, although reflex movements, and the motion necessary to sustain animal life, are often carried on in some animals for a considerable time, when they are born without a brain. But the whole brain does not seem to be absolutely essential to life and mental operations, for many instances are mentioned, where a considerable portion of the brain has been removed by accident, such as a bullet or iron bar being shot through the head followed by a discharge of nervous matter: and yet the persons have lived for years subsequent to the accident in as sound a condition as ever.

608 *a*. Necessity of two Cerebral Hemispheres.—One may be injured, and not the other.—The reason of the division of the brain into lobes or hemispheres is not so easily understood. Perhaps it may be that so large an organ of so soft a substance could not easily sustain its own weight, especially when reclined on one side, and at the same time properly perform its functions. A more probable reason, however, is this. It is a well-known fact, that one of the hemispheres may be diseased or injured, so as to perform its functions imperfectly, and yet the other hemisphere be in its ordinary healthy state. Also one hemisphere may be so much affected, that the opposite side of the whole body is paralyzed in motion or sensation, or both. It then seems reasonable to suppose, that, since the brain would be so liable to injuries, it was made in two portions, so as to prevent the entire destruction of life by an injury to one of the hemispheres.

608. Where are the intellect and the will located? What movements depend on the brain? Is the whole brain absolutely essential for intellection? 608 *a*. Why are there probably two hemispheres to the brain?

609. To secure Precision in all Voluntary Actions:—In Draper's Physiology is found another hypothesis for the division of the brain into two parts: this is to secure precision in the efforts of the intellect and will. "For there is no doubt," he says, "that the hemispheres have not only the power of acting separately, but also conjointly; thus there is no student but must have observed, when busily engaged in reading, that his mind will wander off to other things, though he may mechanically cast his eye over page after page; and the same may occur in listening to a lecture or sermon. But though the insane man may indulge in two synchronous trains of thought, he never indulges in three, for the simple reason that he has not three hemispheres to do it with, the same remark applying to the sane man in the accidental wandering of his thoughts."

610. Thought, Memory, and the Reasoning Powers require a Sound Brain.—As already mentioned, the brain is not the seat of motive power: this does not originate here, although voluntary movements are controlled by it. But automatic or reflex movements, such as the twitching of the muscles of the leg and foot, when the sole of the foot is tickled with some slightly irritating substance, are entirely beyond the control of the cerebrum or will, since they take place nearly as well in a person who is asleep or stunned by a blow, or even when the nerves of sensation and motion are paralyzed. Thought, memory, reasoning, and all the intellectual states demand a healthy and a sound brain for their perfect action, while the ordinary muscular movements and the functions of respiration, circulation, and digestion, are dependent upon the Spinal Cord, Sympathetic Nerve, and Cerebellum.

611. Definition of Sleep.—Need of Sleep.—Sleep, "tired nature's sweet restorer," is a state of the body, in

609. How can two hemispheres secure a precision in voluntary actions? 610. Are reflex movements under the control of the brain? What powers of mind are dependent on the cerebrum?

which there is a more or less perfect suspension of the activity of the brain. The functions of digestion, secretion, and respiration, proceed during the soundest sleep, though with less activity than during the wakeful state. In many cases, however, the functions of the brain do not entirely cease, as is seen in the phenomena of dreaming, where the brain seems to be actively at work, but the senses and animal functions are quiescent. Sleep is demanded by all animals to procure rest to the different organs of the body, and in health it comes to all, though in different degrees of soundness, but generally the greater the exhaustion, the more complete the sleep.

612. Periodical Tendency of Sleep.—The Will can for some Time overcome Sleep.—The tendency to sleep is periodical. All persons feel an inclination to sleep during some portion of the twenty-four hours, and during the night, if health be good and nature not perverted. Some strong intellectual effort, however, or some powerful emotion, will overcome drowsiness for a long time, as in the case of the student working out a difficult problem, or a mother watching her sick child. But when the problem is mastered, and the child has safely passed the crisis, sleep comes on with irresistible force. Cases occur constantly to show that the brain must have its repose in spite of intellectual effort or danger. It is related that boys wearied out with continued labor in the battle of the Nile, slept during a part of the action, and in another naval engagement, a captain slept two hours within a yard of his largest gun, which was kept in action during the whole time. Indians at the stake of torture will sleep on the least remission of agony, but awake as soon as it is renewed again. And we learn that a most barbarous punishment is still practiced in China, that of keeping a victim awake until he dies of sheer exhaustion. The distress of it is said to be terrible.

611. What is sleep? What powers are inactive during sleep, and what processes are carried on during it? What is sleep necessary for? 612. State the fact of a periodical tendency to sleep. Can the will overcome sleep? For how long a time can it do it? Relate the facts mentioned.

613. *Inducements to Sleep.*—Sleep sometimes under the Control of the Will.—Ordinarily darkness and silence promote sleep; but if a person once becomes habituated to noise during slumber—if it be a continuous one—he can not sleep well without it. Thus persons living in the vicinity of forges and noisy mills can not readily sleep elsewhere. And a monotonous repetition of sounds is a most favorable provocative to sleep, the cause of which is that other impressions can not so readily be made on the mind, and thus the sleeper is less easily roused. A dull reader on a dull subject has a most ready effect in producing sleep, as well as the sound of a distant waterfall, or the rustling of leaves in a forest. Rubbing many parts of the skin, or combing the hair by another person, will often cause drowsiness, and sometimes sleep. Again a person can sometimes put himself to sleep, if restless, by a monotonous intellectual effort, such as the rehearsal of a Latin paradigm, or counting the rain-drops, as they fall from the eave trough into the spout.

614. *Effect of Habit on Sleep.*—The effect of habit is powerful in producing sleep. Let one be accustomed to retire early—in accordance with nature—and sleepiness comes at the usual hour for retiring; but if a person for a series of years is in the habit of sleeping the latter part of the night and early in the morning, it is almost impossible for him to sleep early in the night. Those persons who, like sailors, soldiers, and watchers, are obliged to catch sleep when they can get it, and then only in small amounts at a time, sleep with but little difficulty when the opportunity presents itself. Captain Barclay, who walked one thousand miles in as many consecutive hours, had such a power over himself, that he was asleep the moment he lay down. Some physicians have the same power.

613. -What are the common inducements to sleep? Do any persons ever require a noise, in order to sleep soundly? What effect does rubbing or chafing certain parts of the body have upon sleep? Can sleep ever be brought about by an action of the will? How? 614. What effect has habit upon producing sleep? Mention the case of Captain Barclay.

615. Preventives of Sleep.—Any unusual noise or place of sleeping will prevent or disturb the sleep of many persons. Thus the singing of a mosquito keeps many a man awake a long time. But if a noise be repeated often, it will have no effect of this kind. The college Freshman for the few first mornings is readily awaked by the first stroke of the early prayer-bell, but in a short time it has no effect whatever. “A gentleman who had taken his passage on board a man of war, was aroused on the first morning by the report of the morning gun, which chanced to be fired just above his head; the shock was so violent as to cause him to jump out of bed. On the second morning he was again awakened, but this time he merely started and sat up in bed; on the third morning the report had simply the effect of causing him to open his eyes for a moment and turn in his bed; on the fourth morning it ceased to affect him at all, and his slumbers continued to be undisturbed so long as he remained on board.”

616. An Absence of Accustomed Sounds prevents Sleep.—The reverse of this sometimes happens, if there be a cessation of monotonous and unaccustomed sound, by which sleep was induced. Thus a person who has been read or preached to sleep, will awake if the reader or preacher pause or stop, before any disturbance is made, and a person asleep in a railway train, will often awake on the stopping, or even on the slackening of the train.

617. Amount of Sleep.—The amount of sleep necessary for man, varies exceedingly, being affected by the conditions of age, temperament, habit, and exhaustion. Infants and very old people sleep the most. The former require it that the constructive process may go on as uninterruptedly as possible, and they generally sleep three fourths of the time. The latter need a large amount of sleep, because the vital energies are so feeble.

615. What will often easily prevent sleep? Instance the college Freshman and the gentleman on the man of war. 616. How does an absence of accustomed sounds affect sleep? 617. What amount of sleep is necessary? What ages sleep the most?

618. A Lymphatic Temperament a Sleepy one.—Persons of a lymphatic temperament, those who are seldom excited, sleep more than those of a nervous temperament, who are always rapid and quick in their movements. The former live slowly, and but comparatively little waste is going on, and consequently the brain is all the time nearer to sleep than in the latter class, whose brain, when awake, is very active, and when asleep, is asleep very soundly.

619. Effect of Habit on the Amount of Sleep.—Remarkable Cases.—The amount of sleep is greatly modified by habit, and often the briefest sleepers have been men of the greatest activity. If a person acquire the habit of sleeping but little, he must sleep very profoundly, so that what is lost in quantity, is made up in intensity. The habit of taking but little sleep, however, is not a sure indication that a proper amount of it has been secured. Frederic the Great, and John Hunter slept but five hours out of the twenty-four; and General Elliot, engaged in the defense of Gibraltar, and Napoleon, often slept but four hours out of the twenty-four. The general rule, however, seems to be that man should take from six to eight hours of the twenty-four, for uninterrupted slumber. Women in general seem to require rather more.

620. Mode of Access of Sleep.—To some sleep comes on instantly when the will determines upon it, but to others it is a gradual and tedious process, especially in ill health, or an excited mental state. Many physicians drop asleep as soon as the head touches the pillow, and are aroused by no ordinary sound, such as the tread of another person in the room, or the shutting of a door, but wake as soon as the night-bell is rung. Sir E. Codrington, when a young man in the naval service, was very active at one time in looking out for signals,

618. What are the sleepy temperaments? What the wide-awake ones? 619. How does habit affect the amount of sleep? State some remarkable cases. What is an average amount of sleep for men? How much for women? 620. How does sleep come on? Give examples.

and was employed during his waking hours in this business. Hence his sleep was very solid, and he was roused by no ordinary sound, but his comrades amused themselves by whispering the word "signal" in his ear, when he was at once aroused and fit for duty.

621. **Functions of the Cerebellum.**—The Cerebellum does not seem to be in any manner directly connected with the phenomena of mind. But it seems designed simply for the purpose of combining the actions of different muscles, or presides over the coördination of voluntary muscular movements, as in walking, speaking, and similar actions requiring several sets of muscles to be used at the same instant. Accordingly in animals, which possess the greatest variety of movements, we find the largest cerebellum.

622. **Effects when Removed from Animals.**—The Controlling Power of Muscular Motions.—When this organ has been removed from some of the lower animals, it was found that they could not control their movements. When laid down they could not recover their erect posture, and when threatened with a blow, they in vain endeavored to avoid it. Another phenomenon attending a wound, or removal of both sides of the cerebellum, was the motion of the animal in a backward direction, and the rolling from side to side on the longitudinal axis of the body, and keeping up this motion uninterruptedly, for several hours, at the rate of sixty revolutions per minute. In some men who have been afflicted with a disease of this organ, an unsteadiness of gait has been observed, which gives additional strength to the belief that the *Cerebellum is the regulator of muscular movements.*

623. **Functions of the Medulla Oblongata.**—The Medulla Oblongata seems to have for its function the sending of nervous power to the muscles of respiration and swallowing;

621. Does the cerebellum control the phenomena of mind? What are its functions?
 622. What effects does its removal cause in animals? How does a disease of it affect men?
 623. What operations are controlled by the medulla oblongata?

or, in other words, respiration and deglutition are controlled and performed by the medulla oblongata.

624. *Function of the Cerebral Ganglia.*—The series of Ganglia, Corpora striata, Thalami optici, etc., are regarded by Dr. Carpenter as the true sensorium in man, and this is one of the most important facts established with regard to the nervous system. A prominent reason for the belief, that the brain is simply superadded to them, is seen in many instances of children born without a brain, but with the sensory ganglia present, where the functions of animal life have been carried on for a considerable length of time.

625. *Functions of the Spinal Cord.*—The functions of the Spinal Cord are considered in a double aspect: First, as the means of communication between the roots of the spinal nerves, and those parts of the nervous system within the cranium, and second, as a center of nervous power to produce reflex movements when an impression is made upon this cord.

626. *Function of Sympathetic Nerve.*—The Sympathetic Nerve “in its offices is a motor nerve to many of the internal viscera of the body, the heart and the intestinal canal especially; it is also a sensitive nerve to these parts, and it presides over the action of the blood-vessels of these as well as of the other parts, where it is distributed, as of the head and neck, and likewise of all the principal glands of the body.”

627. *Organic Functions depend on the Spinal Cord.*—*Effect of Pressure on this Cord.*—Almost all the functions of organic life, such as breathing, digestion, and circulation, are greatly influenced by the condition of the spinal cord, and especially in its connection with the sympathetic nerve, although the brain has some controlling power. Yet

624. By what set of bodies are the principal functions of animal life carried on? 625. What are the functions of the spinal cord? 626. Give the use of the sympathetic nerve. 627. Upon what portions of the nervous system do organic functions depend?

when we are asleep, or the brain is stunned by a blow, the organic functions are carried on as in the state of the activity of the brain, though with far less energy. And in the case already mentioned of animals born without a brain, life (organic) may be sustained for a considerable time merely by the functions of the spinal cord. If this cord be severed near the head, or even if it be compressed, life soon ceases. This is the manner in which death ensues by hanging, or breaking the neck as it is termed; where one vertebra is slipped from its place (put out of joint), so that by the unequal contraction of the muscles such a pressure is made on the cord that life speedily becomes extinct. And if this cord is compressed in any portion, sensibility and the power of motion in muscles supplied by the part below the point of compression are destroyed; and if the pressure be long continued, or the cord divided, its vitality is for ever destroyed, although the parts above it are only indirectly affected.

628. Sensation Exists Previously to Motion—Centripetal and Centrifugal Fibers—Rate of Movement through the Nerves.—From the fact that one portion of each nerve is designed for sensation, and the other for motion, it is probable that sensation must exist previous to the motion of the part. Thus, for example, if the hand be brought in contact with any substance without any previous knowledge of its presence, no matter how soon the hand may seem to grasp it, yet the interval must have been long enough for the sensation contact to have passed from the hand to the brain, and the will to determine upon the condition of the muscles, and the order to pass down through the white fibers to the hand again before the grasping can take place. Or the same thing may take place on receiving a shock, or series of shocks, from a galvanic battery, the contractions in this case being an instance of involuntary or reflex movement. And although this fact

seems clearly established, that one portion of each nerve transmits the sensation to the brain, called the centripetal or sensory, and the other conveys the order to the muscle, called the centrifugal or motor, yet no anatomical difference can be detected between the different fibers of the nerve. From this fact a German physiologist has made a series of curious calculations, as a result of which he concludes that nervous influence, such as the will to move a certain muscle, travels at the rate of 195 feet per second.

629. *Ganglia Reservoirs of Power.*—It has been suggested, and with reason, that the ganglia, abundant as they are in the body, act as reservoirs of nerve force, and the frequent commissures, or union and subsequent divergence of nerve fibers, is to draw off a part of the influence which is coming along the centripetal fiber, and directing it into a new channel.

630. *Divisions of the Cranial Nerves.*—The cranial nerves may be divided, according to their function, into three groups :

Special Sense.....	}	Olfactory. Optic. Auditory.
Motion.....	}	Motores Oculorum. Patheticus. Abducentes. Facial. Lingual. Trifacial.
Compound.....	}	Glosso-Pharyngeal. Par Vagum. Spinal Accessory.

631. The olfactory nerve is the one by which we gain the smell of odoriferous substances, as they are brought in contact with this nerve in the lining membrane of the nose.

What are the centripetal and what the centrifugal fibers of the nerves? What is a probable rate at which the influence is transmitted through the nerves to and from the brain? 629. What theory has been offered for the use of the ganglia? 630. What three groups of the cervical nerves are here given? 631-640. State the function of each pair of the cranial nerves.

632. The optic nerve, as expanded in the retina, is the nerve of sight.

633. The auditory nerve receives the vibrations of the air, which produce sound.

634. The *motores oculorum*, *pathetici*, and *abducentes* are the nerves which furnish motive power to the eye-ball.

635. The facial nerve is distributed to the muscles of the face, and is the one that aids in the expressions of the emotions and will, as exhibited in the countenance. It is also the channel of the reflex actions in respiration, as when a person involuntarily gasps if cold water be dashed in the face.

636. The lingual (*hypoglossal*) nerve is necessary for the production of articulate speech, regulating and controlling as it does the muscles of the tongue.

637. The trifacial nerve administers the sense of touch to the surface of the tongue, and aids somewhat in the sense of taste. One branch of it is a muscular branch. Another is sent to the mucous surface of the eye, and if it be cut off the eye is destroyed by suppuration.

638. The *glosso-pharyngeal* is the essential nerve of taste, and is closely connected in function with the trifacial. It seems also to be the nerve through which unpleasant sensations excited in the mouth are conveyed to the *medulla oblongata* so as to excite nausea and vomiting.

639. The *par vagum* sends nervous power to the heart-stomach, lungs, and larynx, as well as conveys to the brain any disagreeable sensations excited in these organs. Consequently this is the essential nerve of digestion, respiration, circulation, and opening or closure of the glottis under ordinary circumstances.

640. The spinal accessory seems to be the nerve by which the regulation of the muscles essential to the production of voice is effected.

641. Use of Spinal Nerves.—The use of the Spinal Nerves is to convey impressions made at the surface of the body—including the extremities—to the brain, and to transmit impulses to the muscles from the brain. Both of these influences are transmitted by the same nerve or filament, though in opposite directions. From carefully conducted experiments it seems quite probable that the “coarse fibers” transmit the impulses to the muscles, and are called *afferent*, while the fine fibers conduct the impressions to the brain, and are called *efferent*. And in the muscular nerves the coarse fiber is proportioned to the fine as 10 : 3.3, while in the trunk, as it issues from the spinal cord, it is in the ratio of 10 : 11.

HYGIENIC INFERENCES.

642. The Nervous System not easily Diseased.—1. It is a singular fact that the nervous system, so delicate in its organization and mysterious in many of its functions, is to so small an extent dependent upon any particular rules for the maintenance of its health, the main thing necessary for its welfare being an attendance to the general health of the body.

643. It needs Action.—2. The nervous system, like all other parts of the body, requires action for its health. If a person has nothing upon which he can exert his nervous energy, he is liable to disease; and no class of people are so subject to nervous diseases as the wealthy, who are obliged to make little exertion to procure the necessaries and luxuries of life. Hence we infer that employment of some kind is indispensable to the health of the nervous system.

644. Sleep indispensable to its Health.—3. This system

641. What is the use of the spinal nerves? What is the difference in function between the coarse and the fine fibers? 642. Is the nervous system easily affected by serious disease? 643. What is the necessity of action to the nervous system?

requires sound sleep. For this alone can return to the brain its expended energies. It is as necessary to the brain as steam to the locomotive. And no person can enjoy the perfection of health to old age, who does not gain a due supply of sleep. Hence the very ambitious student, or the man eager to make money, whose time, energies and thoughts are so engrossed that he can not, or will not, find time to sleep, violates one of nature's principal laws, and sooner or later will receive the penalty. And, according to insane hospital reports, one of the principal causes of insanity is put down to a want of sleep.

645. Needs Rest and Recreation.—4. The mind not only needs sleep, but also recreation or an occasional change of its objects of thought. Long-continued trains of thought are to the brain what working one set of muscles incessantly all day is to them—complete exhaustion. He then that would last the longest, must occasionally turn his thoughts from his ordinary avocation completely, and so give the brain rest. This applies to every one, whether he is the business man, student, or the hard-working farmer or mechanic. And every one also needs a vacation, or at least some change of employment, once or twice during the year, when, for a few weeks or days, he may break up the ordinary routine of life.

646. Necessity of various Objects for the Mind to divert itself with.—5. If change or recreation be so important for the health, how necessary that the mind should have various objects on which to employ itself when free from daily duties. How pleasantly, and profitably, for instance, can one pass his leisure hours, if he will but cultivate a taste for music, reading, or some branch of natural history, as for example zoology, botany, mineralogy, or geology! These pursuits not only give healthful physical recreation, but by

644. What is the effect of a want or scarcity of sleep? What is often a prominent cause of insanity? 645. What kind of rest does the mind need besides sleep? Do all employments need a vacation? 646. Is exercise, that is taken simply for exercise, ever the best? What studies combine profit as well as recreation and exercise?

the attractive and fascinating objects of study which they offer, they divert the mind from the ordinary cares and troubles of life, and also exert a healthful moral influence. To literary and professional men, as well as many of business engagements, such a source of recreation and improvement is of very great importance, since often they are not interested in many of the recreations and pleasures which divert the great mass of society, and also because new thoughts and means of illustration may be gained from them.

647. The Brain must be worked Philosophically, not Spasmodically.—6. The brain and nervous system will perform more labor, if worked philosophically, than if worked spasmodically. That is, mental and corporeal labor performed regularly and steadily, and only up to the ordinary power of the brain and nerves to sustain, will not wear away the nervous system to such an extent as if it be performed by overworking for a few days and then lying idle.

648. Value of Mental Abstraction.—7. As a general fact the mind acting through the brain can not successfully work in the midst of noise and external attractions. But by practice many can engage in deep study and intense thought, even in the company of those who are talking, laughing, singing, or in the midst of any noise. This is a valuable acquisition and one that should be sought after by every one, since all of us are liable to be thrown into such circumstances, that we must work, think, and transact business in noise and confusion.

649. The best Time for Study.—8. We see from this subject that the best time for study is in the morning, for then the brain is rested, and can with the greatest vigor and alacrity engage in its efforts. But here the fact presents itself, that the morning is the best time for physical exercise, and to

647. How should the brain and nervous system be worked? 648. What is said of the value of mental abstraction? 649. What is the best time for study?

which shall we give the preference? Shall we deprive our bodies of exercise, or shall we give up the best efforts of the brain? Without hesitancy, *as a general rule*, we should say, attend to the physical exercise first, for if the general health be broken down, the brain will sympathize, and then close mental effort will be at an end. Hence, although morning is the best time for study, yet we must not take the whole of it for that purpose, but must share it with exercise. To a student who is passing through a long course of study, early rising and retiring, and *generally* exercise in the morning before commencing study, will tend to preserve and invigorate health. Studying late at night and sleeping long in the morning, are injurious to no class of people more than to the hard student.

650. Pernicious Effect of Tobacco on the Brain.—9. The effect of tobacco on the brain is thus described, in his medical lectures, by Dr. Solly, an eminent physiologist and practical physician: “I would caution you, as students, from excesses in the use of tobacco and smoking, and I would advise you to disabuse your patients’ minds of the idea that it is harmless. I have had a large experience of brain disease, and am satisfied now that smoking is a most noxious habit. I know of no cause or agent that tends so much to bring on functional disease, and through this in the end to lead to organic diseases of the brain, as excessive use of tobacco.”

651. Power of the Feelings over the Nervous System.—10. It is wonderful and interesting to see what is the power exerted by the feelings and emotions upon the nervous system, and through that upon the whole body. Let the farmer feel that his severe labor is sure to bring him in good crops, and how happily does he persevere in his severe toil month after month. And if the merchant can only know that his

But how shall exercise and study both be properly attended to? What is said of early rising? 650. How does tobacco affect the brain? 651. What effect have the emotions upon the physical system?

gains are great, how incessantly will he work day and night, and yet consider his no hard life. But if there be no encouragement, no prospect of reward to the working-man in his employment, what drudgery does it become! Nay, how positively injurious to health and vigor of body and mind.

652. To the scholar, however, this principle is much more important than to him who labors only with the muscles, since these organs can be worked to a considerable extent with an unwilling mind; but to work a brain already depressed and discouraged is much more difficult, and sure to bring on grave disease. When the spirits are light and the mind free, the memory can be more readily stored with facts and principles, and the reasoning powers more easily developed. It is hence the duty of teachers to make study as pleasant and attractive as possible; it becomes those who select the location and construct the buildings of colleges, academies, and school-houses, to have a reference to taste and comfort in their plans, so that physical inconvenience may not render study irksome, and that the taste of the student may be improved as much as possible by the construction and arrangements of these buildings.

653. Control of the Nervous System by Moral and Religious Feelings.—11. Finally, of all the sources and promoters of health, correct moral and religious feelings and principles are among the most powerful. The reaction of a guilty conscience upon the body, in obstructing the functions and in bringing on weakness and premature decay, is well known. Equally powerful in promoting health and longevity is an approving conscience. A cheerful acquiescence in the divine will has often done more to restore the invalid and maintain good health against disease, than all medical remedies; while pure and ennobling sentiments and religious hopes have sometimes been more efficacious to prolong life on earth than all other hygienic prescriptions.

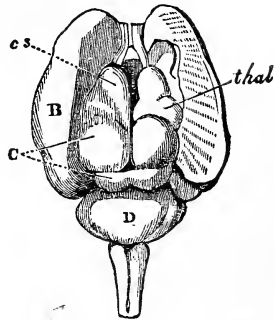
652. What effect has pleasurable feelings on the progress of the scholar? 653. State the value of an approving conscience upon all classes of society, as it simply respects physical health.

COMPARATIVE NEUROLOGY.

654. Among all the higher mammals we are able to trace nearly all the different parts of the nervous system as they are exhibited and arranged in man, though many of them are considerably modified.

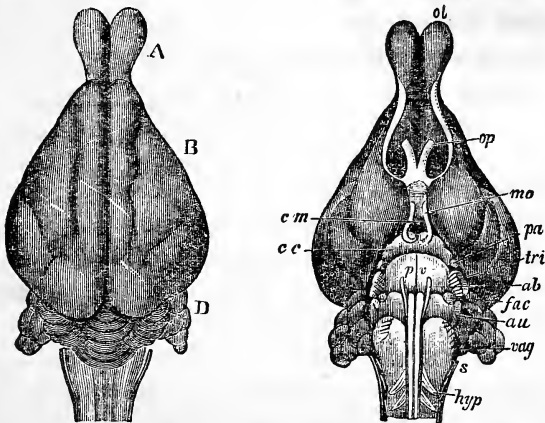
655. Weight of Brains.—The relative weight of the brain is greater in the smaller animals. Thus, in the mouse it is said to be $\frac{1}{4}$ $\frac{1}{3}$ the weight of the body. In the elephant the weight of the brain is

FIG. 329.



Brain of Squirrel laid open. B, Cerebrum. D, Cerebellum. C, Optic Lobes. *thal.*, Thalamus Opticus. *c, s*, Corpus Striatum.

FIG. 330.



Upper and Under Surface of Brain of Rabbit. A, B, D, as before. *ol*, Olfactive Lobes. *op*, Optic Nerve. *mo*, Motor Oculi. *cm*, Corpora Mamillaria. *c, c*, Crus Cerebri. *pv*, Pons Varolii. *pa*, Patheticus. *tri*, Trifacial. *ab*, Abducens. *fac*, Facial. *au*, Auditory. *vag*, Vagus. *s*, Spinal Accessory. *hyp.*, Hypoglossal.

655. What is said of the size of brains?

$\frac{1}{8}\frac{1}{5}\frac{1}{0}$ th the weight of the body; in the ox, $\frac{1}{7}\frac{1}{5}\frac{1}{0}$ th; in the fox, $\frac{1}{2}\frac{1}{9}\frac{1}{5}$ th; while in man it is $\frac{1}{4}\frac{1}{0}$ th the weight of the body.

656. Proportion of the Width of Brain and Spinal Cord in Man and other Mammalia.—This, as well as the comparison of cerebral mass and cerebral nerves, between man and other animals, is interesting. The breadth of the spinal marrow is, to that of the breadth of the brain, in man, as 1:7; in the dog, as 1:2.

657. Cerebral Nerves.—“The cerebral nerves correspond to those of man. The first pair, however, forms in some degree an exception, for though not absent in all the whale family, it is wanting in the dolphins. In most mammals the olfactory nerves are thick and have a cavity in them. The fifth pair of nerves is, in many mammals, of peculiar strength and thickness when compared with that pair in man.”

658. Sympathetic System.—“The nervous system of organic life—the great sympathetic—is formed, as far as investigations indicate, essentially as in man.” It is situated mostly in the cavities of the thorax and abdomen, and follows the course of the blood vessels.

659. Tentorium.—The tentorium cerebelli, which in man is a simple tough membrane that separates the cerebrum from the cerebellum, is very delicate in some animals, as the horse and dolphin; while in the cat it is supported by a bony plate springing from the skull, and is a very firm membrane. Its use to protect the brain in those animals whose movements are at times violent and sudden, and especially those that leap great distances.

660. Spinal Nerves.—The Spinal nerves also, in general appearance, are like those in man. The number of pairs varies in different species, as might be inferred from the differing number of their vertebræ.

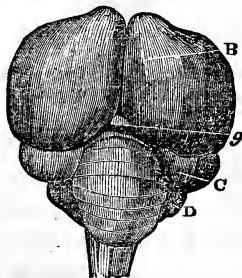
656. State the proportion of the width of the brain and spinal cord. 657. What is said of the cerebral nerves of animals? 658. What is said of the sympathetic system? 659. What is said of the tentorium? 660. What of the spinal nerves of animals?

661. Actual Proportion between Cerebrum and Cerebellum.—According to Cuvier, the proportion of the cerebellum to the cerebrum, by weight, in the baboon, is as 1:7; in the dog, 1:8; in the sheep, 1:5; and in the horse, 1:7.

662. Spinal Cord.—The essential difference between the spinal cord in man and the lower mammalia, is its greater length, and a narrow canal which runs longitudinally through the middle of it.

663. Nervous System of Birds.—The brain of birds is characterized by the smallness of the hemispheres, though more fully developed than in reptiles and fishes. In the sparrow the weight of the brain to the whole body is as 1:25; in the goose, 1:300; and in the cassowary, 1:1000. It is destitute of convolutions, or in other words is perfectly smooth on its surface, and has large cavities or ventricles contained in it: and, as in mammals, the mass of the brain is greater than that of the spinal cord. The pairs of the cerebral nerves are the same as in mammals; also the principal divisions are the same. The cerebellum, as in man, exhibits the arbor vitæ when cut through vertically.

FIG. 331.

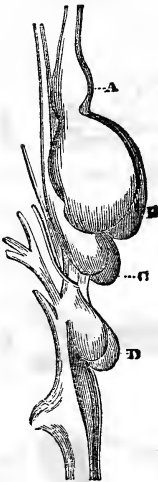


Brain of Buzzard. B, Cerebrum. C, Optic Ganglia. D, Cerebellum. g, Pineal Gland.

664. Nervous System of Reptiles.—The brain of rep-

661. What is the proportion between the weight of the cerebrum and cerebellum in some of the lower animals? 662. What is the essential difference between the spinal cord of man and that of most quadrupeds? 663. How is the brain of birds characterized? Give some of the proportional weights of it compared with that of the whole body?

FIG. 332.



Brain of Turtle. A, Olfactive Ganglia. B, Cerebrum. C, Optic Ganglia. D, Cerebellum.

tiles constitutes but a very small part of the body. In the frog the proportion to the whole weight of the body is as 1 : 172 ; in the Coluber matrix (snake), 1 : 792 ; in a turtle, 1 : 5688. The hemispheres are smooth and hollow internally. The optic lobes are large in proportion to the size of the eyes, and are hollow internally. The cerebellum of frogs is merely a thin plate of nervous matter.

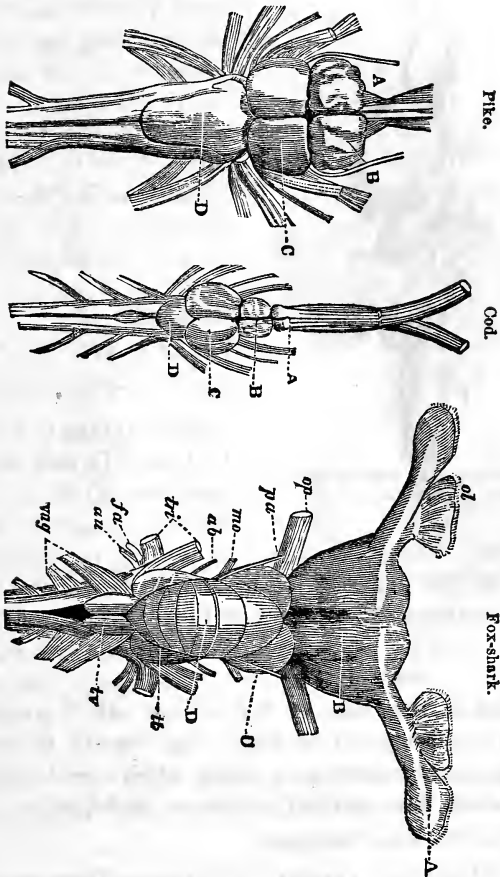
665. Nervous System of Fishes.—We find the lowest development of the nervous system among vertebrates in

the fishes. The brain here does not fill the whole cranial cavity, so that between the brain and dura mater there is found a quantity of loose cellular tissue, with which is interspersed a fluid oil. The brain in weight does not equal that of the spinal cord, nor is it but a little broader than the cord. Its weight in proportion to that of the body is about $\frac{1}{1500}$ th part. It is composed of eight lobes, partly in pairs, and partly unpaired behind one another, which seem to correspond to the cerebellum (divided), corpora quadrigemina, thalami optici, and medulla oblongata.

666. Electrical Organs in Fishes.—There are at least seven species of fish that possess the power of giving electric discharges. The organs which accomplish this in the *Torpedo* are two large crescent-like bodies (see Fig. 334), which are

664. What is said of the brain of reptiles? State its comparative size with that of the whole body. 665. State some of the peculiarities of the brain in fishes. What is its relative weight? 666. What is said of the electrical organs of some fishes? Give the anatomy of these organs.

FIG. 333.



Brains of Fishes. A, Olfactive Lobes or Ganglia. B, Cerebral Hemispheres. C, Optic Lobes. D, Cerebellum. *ol*, Olfactory Nerve. *op*, Optic Nerve. *pa*, Patheticus. *mo*, Motor Oculi. *ab*, Abducens. *tri*, Trifacial. *fa*, Facial. *au*, Auditory. *vag*, Vagus. *tt*, Tubercles or Ganglia of the Trifacial. *tv*, Tubercles of the Vagus.

made up of a large number of short, six-sided prisms, and are abundantly supplied with nerves. And as these organs are made up of prisms, which stand end upon end, and not side by side only, as they appear in the cut, the idea seems

FIG. 334.

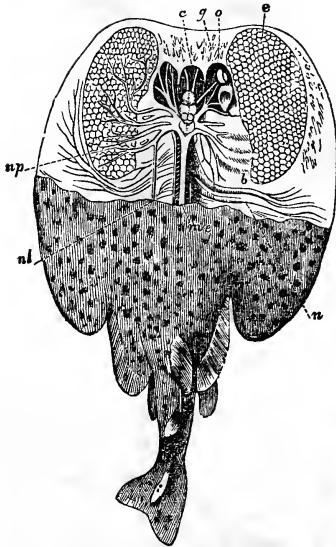


FIG. 335.



Electrical Apparatus of Torpedo. *b*, Branchiæ. *c*, Brain. *e*, Electric Organ. *g*, Cartilage of Cranium. *me*, Spinal Cord. *n*, Nerves to the Pectoral Fins. *nl*, Lateral Nerves to the Body. *np*, Large Nerves (Pneumogastric) to the Electric Organ. *o*, Eye.

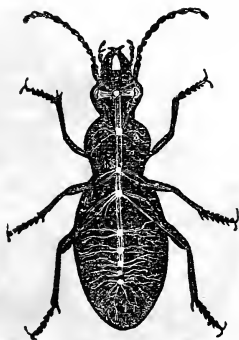
Nervous System of an Articulate.

plausible that they may be regarded as Voltaic piles, or a reservoir of electric power which the fish can discharge at will. And it is necessary for the generation of this electrical discharge that the integrity of the nervous system be maintained.

667. Nervous System in Articulata.—In the Crustaceans the nervous system consists of ganglia and cords. The central ganglion may be regarded as a brain, which sends off nerves of vision, audition, feeling, and smelling. A splanchnic or sympathetic nerve is also found, as in the Arachnoidea and Annelida. The two latter classes have ganglia, which

may be called a brain. In Insects "the central parts of the nervous system consist of a brain and a ventral cord," as is shown on Fig. 336. In some of the lower tribes of Articulates, as the Helminthes and Rotatoria, the nervous system is feebly and indistinctly developed.

FIG. 336.



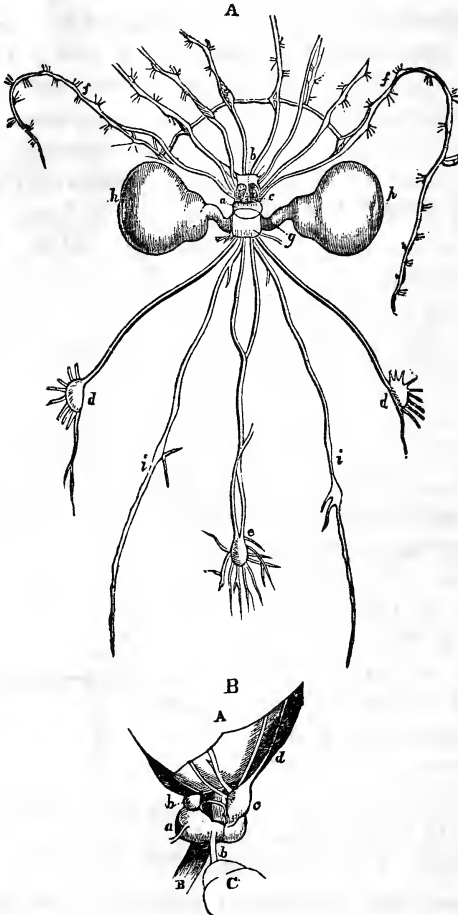
Nervous System of a Beetle.

668. Reflex Actions in Articulates.—This sub-kingdom is remarkable for its reflex actions. Thus if the head of a centipede be cut off while it is in motion, the body will continue to move by the action of its legs; and the same will take place, if the body is divided into several segments. The explanation is as follows. "The body is moved forward by the regular and successive action of its legs, as in the natural state: but its movements are always forwards, never backwards, and are only directed to one side, when the forward movement is checked by an interposed obstacle. Hence, although they might *seem* to indicate consciousness and a guiding will, they do not so in reality: for they are carried on as it were mechanically, and show no direction or object, no avoidance of danger. If the body be opposed in its progress by an object of not more than half its height, it mounts over it, and moves directly onwards, as in its natural state: but if the obstacle be equal to its own height, its progress is arrested, and the cut extremity of the body remains forced up against the opposing substance, the *legs still continuing to move.*"

What is the name of the principal ganglia? 668. What is said of the reflex actions of articulate animals? What are these reflex actions sometimes mistaken for? Give the example.

669. Nervous System of Molluscs.—Cephalic Ganglia.—Pedal Ganglia.—Parieto-Splanchnic Ganglia.—In most of the Molluscs the nervous system is well de-

FIG. 337.

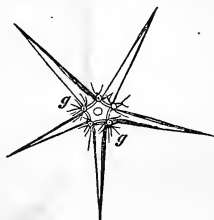


Nervous System of *Argonauta Argo*. A, As seen in front. B, As viewed in profile, showing the relations of the Nervous Centers to the Buccal Mass. A, The Esophagus B, and the Eye c. a, Cephalic Ganglion. b, Buccal Ganglion. c, Sub-Esophageal Ganglion. d, d, Stellate Ganglia of the Mantle. e, Visceral Ganglion. f, Nerves of the Arms, with Ganglionic Enlargements. g, Optic Nerves. h, h, Eyes. i, i, Branchial Nerves with their Ganglia.

veloped; the most so in the Cephalopods, which are the highest in organization. In these we find a central organ quite like a brain, enveloped by a membrane analogous to the Dura Mater. This system is shown on Fig. 337. The general arrangement is that of three principal pairs of ganglia with nerves proceeding from them. The first pair is called the Cephalic ganglia, which is the largest, and is located above or on the sides of the esophagus, with a collar of nerves surrounding that tube. This gives off nerves to the organs of vision and taste, and to the muscular apparatus of the mouth. The second pair, called the Pedal ganglia, is located beneath the esophagus, giving off nerves to the foot and the organs of hearing, when this sense is not actually located in the foot. The third pair, the Parieto-Splanchnic ganglia, are usually found in the posterior part of the body giving nerves to the muscular and sensitive walls of the body, the respiratory apparatus, the heart and large blood vessels.

670. Nervous System of Radiates.—Need of a Nervous System.—Among the higher Radiates a nervous system of inferior organization can be found. For the most part it consists of a ring of nervous

FIG 338.



matter about the mouth, which sends off branches in different directions. “In Medusæ the nervous system consists of a simple cord, of a string of ovate cells, forming a ring around the lower margin of the animal.”—

AGASSIZ. (Fig. 338.) Ganglia, or reservoirs of force can but seldom be found.

Nervous System of Star-Fish. *g, g*, Live Ganglia.

671. Among the Infusoria no nervous system can be detected, and if any exist, its participation in the general course

669. What is the principal arrangement of the nervous system among molluscs? 670. What is the nervous system of the radiates? 671. How is the nervous system among Radiates?

of vital action must be very trifling. For the simplest office of a nervous system is to establish a communication between the different parts of the body; but if every part of the body has similar endowments, there can be no object in such communication. For instance, where every part of the surface—as is the case in those animals—is equally susceptible of absorption, there can be no need of a circulating system, and where contractility seems to be diffused through the body alike, a nervous system would be superfluous.

671. What of the nervous system of Infusoria.

CHAPTER EIGHTH.

THE INLETS TO THE SOUL.—THE SENSES.

GENERAL REMARKS.

672. *The Senses.*—Dependent on the Mind.—These are commonly known under the name of senses. Five are usually reckoned, Seeing, Hearing, Tasting, Feeling, and Smelling; and it is by these alone that we are made acquainted with external objects. In other words, sensation may be defined as the consciousness of impressions. The mind, for aught we know, might be able to carry on its functions of thinking, reasoning, and memory, and also be conscious of its own existence, if it were deprived of the senses: but it could not make itself felt on other minds, nor increase in knowledge and discipline without their aid. And although the primary object of the senses is to promote physical enjoyment, yet their highest and noblest use is to subserve the purposes of the mind.

673. *Senses best Developed in Lower Animals.*—In man the senses are not so fully developed as in most of the lower animals. But this deficiency is much more than compensated by the superiority of his intellect.

674. *Effect of excessive Use of the Senses.*—Excessive indulgence of any of the senses is apt to produce painful instead of pleasurable sensations. Thus heat of a moderate

672. What are the inlets of the soul? Is mind necessary for the existence of sense? What is the primary use of the senses? What should be their highest use? 673. In what animals are the senses the most perfectly developed? 674. How does excessive indulgence affect the senses?

temperature is always agreeable, but painful if much increased. Many odors snuffed in small quantity are pleasant, but when given to satiety, become disgusting. The probable design of this provision seems to be to prevent injury by an inordinate stimulation of any of the nerves. For instances are on record, where the mucous membrane of the nostrils has been severely affected by the fumes of ammonia given in fainting.

675. Habit makes painful Sensations pleasant.—It is a curious but interesting fact that the pain excited by unaccustomed sensations may sometimes be exchanged for its opposite, after the system has become habituated to them. Thus tobacco and alcoholic liquors are at first disagreeable to most persons; but when the disgust has been overcome by any means a love for them succeeds, and generally a strong craving for excessive indulgence also.

676. Nerves of Special Sense can perform but one Function.—The nerves of special sense are incapable of performing any function except that for which they were originally designed. Thus the optic nerve can perform the function of vision only, the olfactory only that of smelling, and the auditory only that of hearing.

677. Effect of Belief on our Sensations.—The effect of previous belief in modifying our sensations, is shown in the two cases copied from Carpenter's Physiology. "A clergyman told me that some time ago suspicions were entertained in his parish, of a woman who was supposed to have poisoned her newly born infant. The coffin was exhumed, and the procurator fiscal, who attended with the medical men to examine the body, declared that he already perceived the odor of decomposition, which made him feel faint, and in consequence he withdrew. But on opening the coffin, it was

What instance of this from odors? 675. How does habit sometimes affect painful sensations? What examples? 676. What is said of the function of the nerves of special sense? 677. How does our belief affect our sensations? Give the instance of the infant.

found to be empty; and it was afterwards ascertained that no child had been born, and consequently no murder committed. The second case is yet more remarkable. A butcher was brought into the shop of Mr. McFarlan, the druggist, from the market place opposite, laboring under a terrible accident. The man on trying to hook up a heavy piece of meat above his head, slipped, and the sharp hook penetrated his arm, so that he himself was suspended. On being examined, he was pale, almost pulseless, and expressed himself as suffering the acutest agony. The arm could not be moved without causing excessive pain; and in cutting off the sleeve, he frequently cried out: yet when the arm was exposed, it was found to be quite uninjured, the hook having only traversed the sleeve of his coat!'"

THE SENSE OF VISION.

DEFINITIONS AND DESCRIPTIONS.

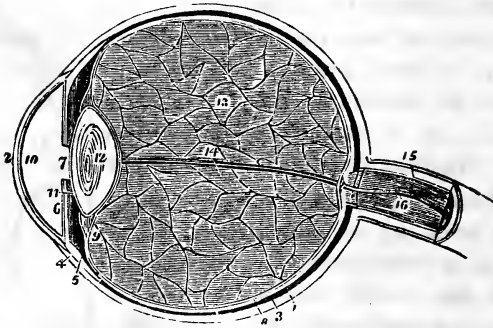
678. The chief organ of this sense is the eye, although its appendages perform very important secondary functions.

679. *Anatomy of the Eye.*—The human eye is nearly globular in form, with a diameter a little less than one inch, the lateral diameter being one twentieth of an inch less than the antero-posterior. (Fig. 339, p. 370.) In general structure it is made up of three membranes, and three humors, or transparent media, and is covered on the surface exposed to the air by mucous membrane, which also lines the inside of the lid, so that the two surfaces at some points are always in contact.

680. *Sclerotica.*—The membrane which covers the larger portion of the eye is called the Sclerotica, from the Greek

Give the instance of the butcher. 678. What is the chief organ of sight? - 679. What is the shape of the eye? Its diameter? Of how many media and membranes is it made up?

FIG. 339.



Longitudinal Section of the Globe of the Eye. 1, Sclerotic, thicker behind than in front. 2, Cornea, received within Anterior Margin of Sclerotic, and connected with it by means of a beveled edge. 3, Choroid, connected anteriorly with (4,) Ciliary ligament, and (5,) Ciliary Processes. 6, Iris. 7, Pupil. 8, Third Layer of Eye, Retina terminating anteriorly by abrupt border at commencement of Ciliary Processes. 9, Canal of Petit, encircles the Lens (12); the thin layer in front of this canal is the Zonula Ciliaris, a prolongation of Vascular Layer of Retina to the Lens. 10, Anterior Chamber of Eye containing Aqueous Humor; the lining membrane, by which the humor is secreted, is represented in diagram. 11, Posterior Chamber. 12, Lens, more convex behind than before, enclosed in its proper Capsule. 13, Vitreous Humor enclosed in Hyaloid Membrane, and in cells formed in its interior by that membrane. 14, Tubular Sheath of Hyaloid Membrane, which serves for the passage of the Artery of Capsule of the Lens. 15, Neurilemma of Optic Nerve. 16, Arteria Centralis Retinae, embedded in the center.

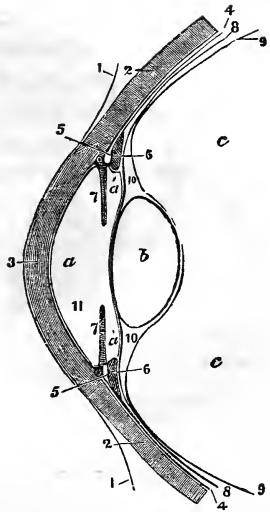
signifying hard, because it is a firm and stout membrane. Its color is nearly white, covering the posterior four fifths of the eye, it is commonly called the white of the eye, and is thickest in its posterior parts.

681. Cornea.—The external covering of the front fifth part of the eye is called the Cornea, from the Latin word meaning horn-like, and in two respects it bears the same relation to the ball of the eye, as the crystal does to the watch, since it is fitted into the sclerotic by a beveled edge, as is a watch-glass, and also because it is perfectly transparent. The blood-vessels of this membrane are among the smallest in the body, being too small to allow the passage of the blood-corpuscles, and only convey the plasma or serum.

680. Describe the sclerotic coat. 681. What is the cornea? To what may it be compared in the watch?

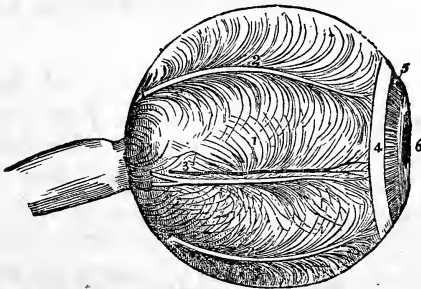
682. Choroid Coat.—Iris.
 —Ciliary Processes.—The middle coat of the eye is made up of three portions, the Choroid membrane, the Iris, and the Ciliary processes. The first, Choroid, is named from the fact that it is entirely made up of blood-vessels, of a chocolate-brown color on the outside, and a deep black on the inside. It covers the posterior four fifths of the eye, and corresponds to the sclerotic coat outside of it. The Iris, so called from the diversity of color which

FIG. 340.



Plan of the Structures in the Fore Part of the Eye, seen in Section. 1, Conjunctiva. 2, Sclerotica. 3, Cornea. 4, Choroid. 5, Annulus Albidus; before this is seen the Canal of Fontana. 6, Ciliary Processes. 7, Iris. 8, Retina. 9, Hyaloid Membrane. 10, Canal of Petit (made too large). 11, Membrane of the Aqueous Humor (too thick.) a, Aqueous Humor; Anterior Chamber, and (a,) Posterior Chamber. b, Crystalline Lens. c, Vitreous Humor.

FIG. 341.

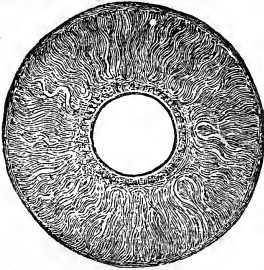


Choroid Coat of the Eye. 1, Curved lines marking the arrangement of Vena Vorticosae. 2, 2, Ciliary Nerves. 3, A long Ciliary Artery and Nerve. 4, Ciliary Ligament. 5, Iris. 6, Pupil.

682. Of what three portions is the choroid coat composed? Give their names. Describe the Iris.

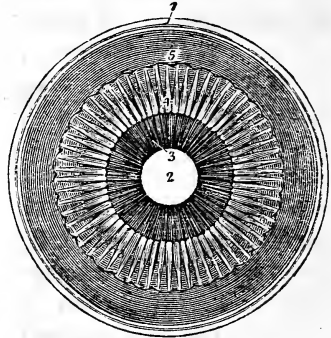
it presents in different persons—and it is the color of this which we mean when we speak of the color of the eye—corresponds in position to the cornea lying immediately under it.

Fig. 342.



External View of the Iris.

Fig. 343.



Anterior Segment of a Transverse Section of the Globe of the Eye seen from within.

1, Divided edge of the three Tunics; Sclerotic, Choroid (the dark layer), and Retina. 2, Pupil. 3, Iris, the surface presented to view in this section being the Uvea. 4, Ciliary Processes. 5, Scalloped Anterior Border of the Retina.

It is circular in form, containing a few muscular fibers, with a circular opening through its center, from one third to one twentieth of an inch in diameter, which is known as the pupil. The Ciliary processes are minute triangular folds of the Choroid coat, which lie upon the interior surface of the iris, with their bases directed toward the pupil. They are about sixty in number, and are divided into large and small, the latter being placed between the former. The Pigmentum Nigrum, or black paint, is an extremely tenuous membrane, which lines the inside of the choroid coat. It is of a jet black color, and is easily destroyed merely by allowing a stream of water to fall upon it.

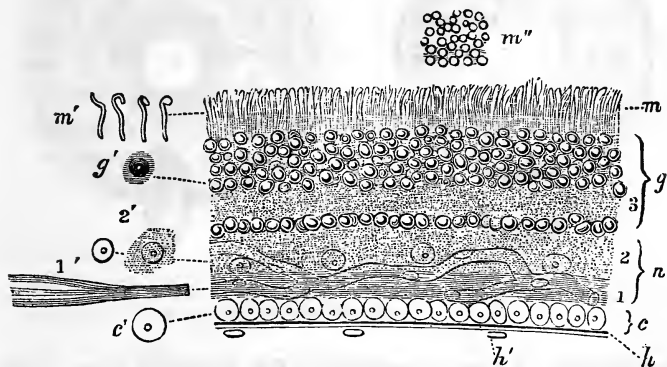
683. *Retina*.—The inner membrane of the eye is the *Retina*, which is merely an expansion of the optic nerve, upon

What is the diameter of the iris? What are the ciliary processes? How many are there? What is the pigmentum nigrum? 683. Describe the retina.

the inner side of a hollow sphere, formed by the membranes already mentioned.

684. Microscopic Structure of these Membranes.—The structure of these membranes, as revealed by the microscope, is very complex. The Cornea is made up of four simple membranes, the Choroid of three, and the Retina of four.

FIG. 344.



Vertical Section of the Human Retina and Hyaloid Membrane *h*, Hyaloid Membrane. *h'*, Nuclei on its inner surface. *c*, Layer of Transparent Cells, connecting the Hyaloid and Retina, *c'*, Separate Cell enlarged by imbibition of water. *n*, Gray Nervous Layer, with its Capillaries. 1, Its Fibrous Lamina. 2, Its Vesicular Lamina. 1', Shred of Fibrous lamina detached. 2', Vesicle and Nucleus detached. *g*, Granular Layer. 3, Light Nuclei frequently seen. *g'*, Detached Nucleated Particle of the Granular Layer. *m*, Jacob's Membrane. *m'*, Appearance of its Particles, when detached. *m''*, Its Outer Surface.—Magnified 320 diameters.

The Sclerotic is for the most part made up of white fibrous tissue, and a large portion of the Choroid coat is composed of blood-vessels, although the inner membrane—the Pigmentum Nigrum or black paint—consists of minute six-sided cells resembling a tessellated pavement. The Retina is for the most part made up of the different forms of nervous tissue and its membranes.

684. Give the microscopic structure of the cornea. Of the choroid, the pigment, and the retina.

685. **Humors of the Eye; Aqueous.**—Of the three Humors or liquid substances composing the eye, the Aqueous or watery is situated in the anterior portion of this organ behind the cornea, and in front of the crystalline humor soon to be described. It is a liquid like water, with an alkaline taste, and only a few drops in quantity. The Iris is placed directly in the middle of this fluid.

686. **The Lens.**—The Crystalline Lens or Humor (so called because it refracts light and is transparent like a crystal) is a double convex lens, the posterior convexity being

FIG. 345.



Front View of the Crystalline Lens.

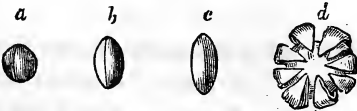
FIG. 346.



Side View of the Lens. 1, Anterior Face. 2, Posterior Face. 3, Circumference.

greater than the anterior, and is located directly behind the pupil, so that all the light which enters the eye, must pass through this and be refracted. This lens is made up of concentric layers like an onion, and also of three triangular segments, with their sharp edges directed towards the center, both of which structures, by boiling the lens in water for a short time, can be readily seen. Fig. 347 represents the

FIG. 347.



Crystalline Lens. *a*, At birth. *b*, At six years old. *c*, Adult. *d*, Altered by alcohol.

difference in diameters of the lens at different periods of life. *a*, represents it at birth, *b*, at six years of age, *c*, its appearance in an adult, and *d*, after it has been

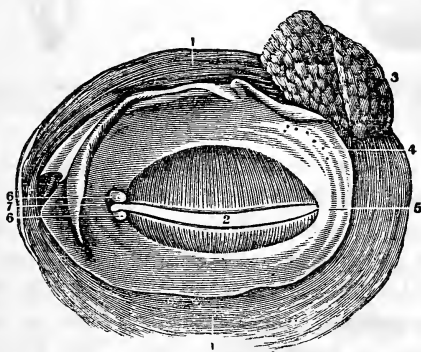
685. How many humors are there in the eye? Describe the aqueous. 686. What is the crystalline humor? What kind of a lens is it? Of how many segments is it made up?

hardened and partially divided into segments by an immersion in alcohol.

687. *Vitreous*.—The *Vitreous Humor* (from its resemblance to glass) is of the form of a sphere, with the anterior portion removed, and constitutes seven eighths of the globe of the eye. It is a transparent fluid enclosed in a transparent membrane, and through its central portion from the entrance of the optic nerve, there passes a small artery to the lens, which supplies it with blood.

688. *Lachrymal Gland*.—*Nasal Duct*.—At the outer angle of each eye is found a gland called the *Lachrymal gland*, nearly three fourths of an inch in length, and of a flattened oval

FIG. 348.

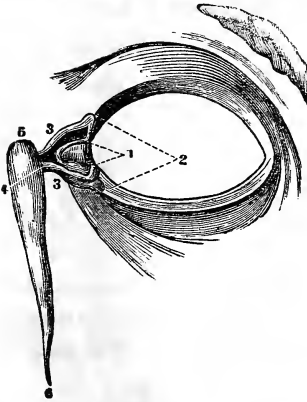


Posterior View of the Eyelids and Lachrymal Gland. 1, 1, *Orbicularis Palpebrarum* Muscle. 2, Borders of the Lids. 3, *Lachrymal Gland*. 4, Its Ducts opening in the Upper Lid. 5, *Conjunctiva* covering the Lids. 6, *Puncta Lachrymalia*. 7, *Lachrymal Caruncle* as seen from behind.

shape. (Fig. 348.) Passing from this gland to the eye, are from eight to twelve small ducts, which open upon the under side of the lid near its edge, about one twentieth of an inch apart, which carry the tears to the eye. By continual winking this

687. From what does the vitreous humor get its name? Describe it. 688. Where are the lachrymal glands situated? What is their size? How many ducts have they? What do they secrete? Of what use is winking?

FIG. 349.



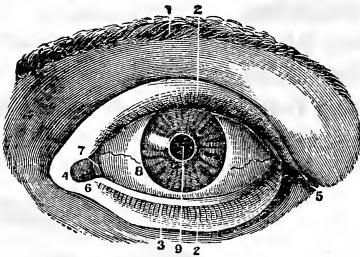
Lachrymal Canals. 1, Puncta Lachrymalia. 2, Cul-de-Sac at the Orbital End of the Canal. 3, Course of each Canal to the Saccus Lacrymalis. 4, 5, Saccus Lacrymalis. 6, Lower Part of the Ductus ad Nasum.

fluid is uniformly distributed over the whole ball of the eye, and the excess is carried away from the eye by the two lachrymal canals, which commence at the two little projections near the inner angle of each lid of the eye, appearing like minute black specks. Both of these very soon unite into a larger tube called the nasal duct, (Fig. 349,) which descends inwardly and empties itself upon the nostrils.

689. Eyebrows.—

The Eyebrows are projecting arches of fat and skin, covered with short and thick hairs which encircle the upper portion of the eye. They are provided with muscles, so that they can be made to shade the eye more or less perfectly, as necessity may require.

FIG. 350.



Front View of the Left Eye—moderately opened. 1, Supercilia. 2, Cilia of each Eyelid. 3, Inferior Palpebra. 4, Internal Canthus. 5, External Canthus. 6, Caruncula lacrymalis. 7, Plica Semilunaris. 8, Eyeball. 9, Pupil.

690. Eyelids.—

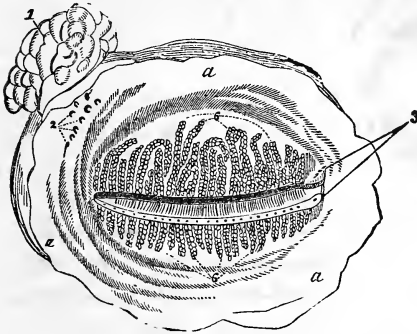
The Eyelids are movable membranous and muscular coverings which are placed directly upon the eyeball, and are

designed for protective organs against mechanical violence and too powerful light. Their free edges are called Tarsal Carti-

Where are the lachrymal canals and what do they carry? What is the nasal duct? 689. Describe the eyebrows. 690. What are the eyelids? What are their edges made up of? What glands directly in them?

lages, directly in the substance of which is placed a large quantity of minute glands, called Meibomian Glands.

FIG. 351.



Meibomian Glands seen from the Inner or Ocular Surface of the Eyelids, with the Lachrymal Gland—of the Right Side. *a*, Palpebral Conjunctiva. 1, Lachrymal Gland. 2, Openings of Lachrymal Ducts. 3, Lachrymal Puncta. 6, Meibomian Glands.

FIG. 352.

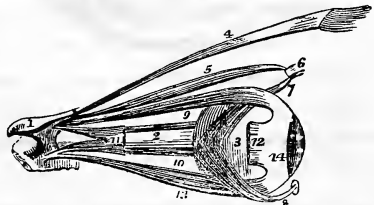


Meibomian Gland highly magnified.

691. Muscles of the Eye.—The Ball of the eye is moved by six distinct muscles, four straight and two oblique muscles, as is shown in the cut. Their names are Rectus Superior and Inferior, External and Internal, and Superior and Inferior Oblique.

Muscles of the Eyeball. 1, A small Fragment of the Sphenoid Bone around entrance of Optic Nerve into Orbit. 2, Optic Nerve. 3, Globe of Eye. 4, Levator Palpebræ Muscle. 5, Superior Oblique Muscle. 6, Its Cartilaginous Pulley. 7, Its reflected Tendon. 8, Inferior Oblique Muscle; the small square knob at its commencement is a piece of its bony origin broken off. 9, Superior Rectus. 10, Internal Rectus almost concealed by Optic Nerve. 11, Part of External Rectus, showing its two heads of origin. 12, Extremity of External Rectus, at its Insertion; the intermediate portion of muscle having been removed. 13, Inferior Rectus. 14, Tunica Albuginea formed by expansion of tendons of four recti.

FIG. 353.



691. How many muscles for moving the eyeball? Give their names.

FUNCTIONS OF THE EYE.

692. The primary and obvious use of the eye is to receive the form and color of different objects, and to transmit them to the brain.

693. Use of the Coats—Sclerotica—Cornea—Choroid—Black Paint—Iris—Ciliary Processes—The Retina.—The use of the firm and hard sclerotic coat is to give a firm attachment to the muscles which move the eye, and also secure protection to the delicate parts within. The cornea is tough but transparent, so that the anterior portion of the eye may be firm and at the same time admit the rays of light. The choroid coat furnishes the blood to the eye, it being for the most part entirely made up of blood-vessels. It also secretes the black paint (Fig. 288), which is of great service in absorbing the superfluous or wandering rays of light which otherwise would obscure the image on the retina. A similar provision is made by painting black the tube of the telescope and microscope. The iris regulates the amount of light entering the ball, by its contraction and expansion. This function is performed by the radiated and circular muscular fibers, the latter of which contract by the stimulus of strong light; but if the light be feeble, the radiated contract, and thus enlarge the pupil. The retina, with the vitreous humor in front and the black paint directly behind it, receives the image of the object before the eye. It bears the same relation to the other parts of the eye as the silvered or glass plate does in the camera of the photographer. This impression is carried to the brain by means of the optic nerve.

694. Use of the Humors—Aqueous—The Lens—Vitreous.—Of the three humors or media of the eye, the aqueous is the least important, since if by accident or operation it is re-

692. State the use of the eye. 693. Give the use of the sclerotic coat. Of the cornea. What does the choroid furnish to the eye? Of what service is the black paint? What does the iris do? What is the function of the ciliary processes? What is the use of the retina? 694. Which is the least important of the humors?

moved, nature will soon replace it; but this is true of no other medium. The aqueous humor, however, is of great use to keep the front parts of the eye in a soft and elastic condition, and also to furnish a medium in which the iris may readily be contracted and relaxed. It also aids in properly refracting the rays of light, so that the most perfect image may be formed on the retina. The use of the crystalline lens is also to refract the rays of light, so that an image of sufficiently small size may be formed on the retina. Otherwise, when we look at any object larger than the diameter of the pupil, we should be unable to see it, only by successively looking at minute portions of it. The vitreous humor assists in the same refraction of the rays, and incidentally subserves the purpose of fixing at a proper distance the lens, so that the image may be formed exactly at that point on the retina called the focus, where it will be the most distinct.

695. *Need of Three Media.*—But what is the necessity for three media of refraction, and why will not the crystalline lens answer the whole purpose? This is owing to some of the properties of light. Light is composed of seven rays or colors, some of which are more easily refracted than others; that is, some rays are bent farther from a perpendicular to the surface than others. Hence, upon the edges of an image formed by a single lens, every part of which is of the same density, we should see several of the prismatic colors, which would give an indistinct image. In the telescope and microscope this difficulty is remedied by forming a lens of crown and flint glass, one of which has a stronger dispersive or refractive power than the other. In the eye the same error is obviated by means of the crystalline lens, which has a greater refractive power than the vitreous humor, and consequently, when the ray is too much refracted by the crystalline lens, a com-

State the use of the aqueous. The use of the lens. What does the vitreous humor aid in? 695. What is the need of three humors? How many distinct colors does light consist of? What similar purpose do lenses of different densities answer in telescopes? Which of the three humors has the greatest refractive power?

pensation is effected by the vitreous humor, which refracts less than the lens.

696. *The Secretion of the Lachrymal Glands.*—The lachrymal gland is designed to secrete a saltish fluid known as the Tears. This is of great service in lubricating and keeping moist the surface of the eyeball, so that it may move readily in its socket, and also to keep the cornea from becoming hard and dim. The tears also moisten the back part of the nostrils, and are ultimately poured into the pharynx. The amount of tears which is daily secreted is estimated at four ounces, and it is greatly increased by strong emotions, whether pleasant or sorrowful, as it is well known that a person is apt to cry when very sad or very happy.

697. *Service of the Eyelids—Necessity of Constantly Winking—Eyelashes.*—The eyelids are of service to keep the light from the eyes when it is too intense, or when it is necessary to exclude it entirely, as during sleep. Another valuable service which they perform is to spread the tears constantly and uniformly over the eyeball. This is the reason why we are constantly but unconsciously winking during every few seconds of our waking hours. The eyelashes which line the edges of the lids, prevent the perspiration which is secreted on the lids from entering the eye, and thus irritating it, since by the law of capillary attraction the tears will run towards the free extremity of the hair, where they will accumulate to such a size that they drop off. The eyelashes also prevent, in some degree, dust from entering the eye.

698. *Use of the Eyebrows.*—The eyebrows perform a similar office to the eyelids, though not so important. The hairs which cover them, like the lashes, convey away the perspiration from the forehead, and allow it to fall in front of the eye, and not directly upon the ball; while, by means of the

696. What is the secretion of the lachrymal gland? What is the use of the tears? What quantity of tears are secreted daily? 697. Of what service are the eyelids? Why do we constantly wink? Of what service are the eyelashes? 698. What service do the eyebrows perform?

muscles attached to the integuments, whenever it is desired they bring the brows in front of and above the eye in such a manner as to afford it a very considerable protection from excessive light.

699. *Short and Long-Sightedness.*—The phenomena of short and long-sightedness are worthy of a passing notice. Short-sightedness results where the lens of the eye has too much convexity, which causes the image to be formed in front of the retina. In such persons the eye generally has greater prominence than in others. But persons thus affected will probably in later years have better eye-sight than if short-sightedness had not existed. A too much flattened state of the lens occurs in those who are long-sighted. This is generally the case with those somewhat advanced in life. In this case the distinct image will be formed behind the retina, and it requires a convex lens, in the form of spectacles, to correct the error.

700. *Other Interesting Phenomena of Vision.*—A few other phenomena connected with the function of vision deserve attention. One is the fact, that although we have two eyes and two distinct images are transmitted to the brain, yet but one object is seen. And if we look at an object with only one eye, we see the image nearly as distinct as with both eyes. Another is, that although the image on the retina is inverted, yet to the mind it appears in its true position. For, since the rays of light pass through the lens in nearly straight lines, the ray coming, for instance, from the top of a tree, will fall upon the lowest part of the retina, while the ray coming from the bottom will strike the upper part, and hence the image will be inverted, although to the “mind’s eye” it will be erect. Another fact is equally wonderful. We are able to see with distinctness an object only a few inches from our

699. What is the cause of short-sightedness? What is the reason of long-sightedness? What kind of a lens is required for long-sighted people, and why? 700. What curious facts connected with the physiology of vision?

eyes, and almost instantly, by turning them to a mountain top several miles distant, we can see an object there with perfect clearness. No optical instrument can be made which will so quickly do this, for it is necessary to make a new adjustment of the lenses to adapt it to different distances, but the eye is at once ready. It is supposed that this adjustment is effected by a shortening or lengthening of the diameter of the crystalline lens, or by drawing the lens towards the posterior part of the eye, by means of a few muscular fibers called the ciliary muscle, running from the bones of the nose to the cornea, which by their contraction would force the aqueous humor upon the crystalline lens in such a manner as to flatten it, and by a relaxation of the same fibers a dilatation in an antero-posterior direction is effected, and that instantly.

701. Experiment for Seeing the Arteries of one's own Eye.—The image of the arteries of one's own eye can be readily seen in the following manner. In a dark room place the left hand over the left eye, and in the right hand hold a lighted candle by the right side of the head, and very near to it. Then with the right eye open, looking towards the darkened wall, move the candle up and down rather quickly, and in a few seconds dark branches will appear at a short distance from the eye, looking like the limbs of a tree, which are images of the arteries distributed on the retina.

702. Limits of Vision.—What is the size of minute objects that can be seen by the naked eye? Ehrenberg, an eminent microscopist, says that nearly all eyes have equal power to discern minute objects, whether long or short-sighted. The smallest square magnitude visible to the naked eye, either of white particles on a dark ground, or the reverse, is about the $\frac{1}{400}$ th of an inch. Brilliant particles which pow-

How is the telescopic and the microscopic power of the eye explained? 701. How can we see the image of the arteries of our own eyes? 702. What is the smallest square surface that can be seen with the naked eye?

erfully reflect light may be distinctly seen when not half the size of the foregoing. Thus gold dust the $\frac{1}{1125}$ th part of an inch in diameter is visible in common daylight. Lines may be more readily seen than points. Opaque threads $\frac{1}{4900}$ th of an inch in diameter can be seen when held towards the light. Attention also greatly helps to discern minute objects, or at least to retain them in sight when once pointed out. Thus we are often able to see a faint star in the sky or a ship in the horizon after they have been pointed out to us, although they were not seen before. "I myself," says Ehrenberg, "can not see $\frac{1}{2700}$ th of an inch, black or white, at twelve inches distance; but having found it at from four to five inches distance, I can remove it to twelve inches and still see the object plainly."

703. Color Blindness.—Many people are afflicted with an inability to distinguish certain colors of the solar spectrum. This is called Color Blindness, or Daltonism.

704. Formerly it was supposed that this affection was very rare, but later researches show it to be quite common. According to experiments made by Dr. Wilson upon 1154 persons in Edinburgh in 1852 and 1853, it was found that—

- 1 in 55 confounds red with brown.
- 1 in 60 confounds brown with green.
- 1 in 43 confounds blue with green.

Hence one in every 17.9 persons is color blind.

THE SENSE OF VISION IN ANIMALS.

705. Tapetum—Pupil—Nictitating Membrane—Harderian Gland.—The general anatomy of the eye of mammals differs but slightly from that of man. Between the sclerotic and choroid in some animals is found another membrane of a

How is it with brilliant particles? How is the ready vision of lines compared with points? How small a thread can be seen by the naked eye? What effect has the familiarity with an object? 703. What is color blindness? How often is this peculiarity found? What colors are most commonly confounded?

metallic brilliancy, with different shade of color, known as the Tapetum. In horses and cows it has a variegated luster of green and blue, while in the tiger, cat, and whale it is of a silvery brightness. The shape of the pupil in the wolf and dog, which need vision in all directions, is circular; while the fox and cat, which need a vertical range more than any other, have a perpendicular slit only. In cattle and the more timid grazing animals which obtain their food from the ground, and need to look behind with ease when pursued, the pupil is a horizontal ellipse. Nearly all mammals except man and the apes, have a third lid, which is a transparent membrane that is frequently slid over the ball by a peculiar muscular apparatus. This is called the "haw" or Nictitating Membrane, and, especially in birds, serves the purpose of removing impurities from the eye, and also of spreading the secretions over it, in order to keep it moist and transparent. In addition to the lachrymal gland, in all animals which have the third lid there is another gland called the Harderian Gland, which prepares another secretion similar to and for nearly the same purpose as the lachrymal.

706. Eyes of Birds—Pecten Marsupium.—All birds, without exception, are provided with perfect and well developed eyes. They are always large, and largest in birds of prey. They are but slightly movable themselves, but this want of motion is compensated by the great mobility of the head. The sclerotic coat is strengthened in front by a series of bony plates, fourteen or fifteen in number, interposed between its fibrous layers, a great use of which is to give attachment to the special muscular apparatus for adapting the eye to see objects at different distances. The anterior chamber is proportionally larger than in any other animals, so that the iris is far back from the cornea. The iris has different shades of color, commonly yellow or brownish. The yellow color of

705. What is the tapetum? What is its color? What is the shape of the pupil in the wolf, dog, and in cattle? What is the Nictitating membrane? Of what service is the "haw"? For what purpose is the Harderian gland? 706. What is said of the perfection of eyes in birds? How is the sclerotic coat strengthened in them?

this part in the owl is owing to the presence of cells containing fat. A curious structure is found in the eye of birds that is found in no other animal. It is called the "Pecten Marsupium," and consists of a layer of blood-vessels arranged in several plications varying greatly in size. It extends sometimes as far forwards as the lens, and is covered by black pigment. Its probable use is that of absorbing rays that enter the eye obliquely, and thus rendering sight from a forward direction more definite and sharp. The membrana nictitans and the Harderian glands are present in these animals in their fullest perfection.

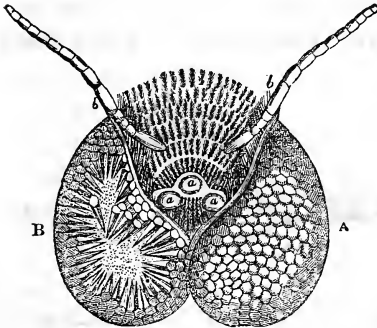
707. *Eyes of Reptiles.*—All reptiles have two eyes. In most, especially in serpents, they are small in comparison with the size of the body; in the frog, however, in the gechos and chameleons they are large. In some they are covered by the skin. In the serpents there are no eyelids, but the skin which covers them is kept moist by a lachrymal gland, and thus performs the service of a lid. In other reptiles there are three lids, the middle one of which moves at right angles to the other two. The lachrymal gland often is very large. In some turtles and lizards there is a ring of bony plates which supports the eyeball. The lens has different degrees of sphericity in different animals.

708. *Eye of Fishes—Pigmentary Spots.*—The eyes of fishes are remarkable for the great size and spherical form of the lens, which is necessary in order to give sufficient refraction to the rays of light that come from the dense medium in which they live. The size of the lens varies greatly, being largest in the bony fishes and smallest in those which lie buried in the mud like the eel. The lowest stage, however, is seen in the amphioxus, a condition which greatly resembles

What makes the yellow color of the iris in birds? What is the pecten marsupium? What is its use? 707. What is said of the eyes of reptiles? What of the bony plates in the eyeball? 708. What characterizes the eyes of fishes? What ones have the largest?

that of the lowest invertebrata, being nothing but two pigmentary spots. The eye is but slightly movable in fishes, since the body, and consequently the head, can be so readily moved in any direction through the water.

FIG. 354.

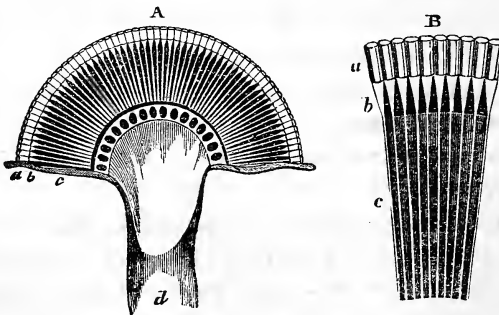


Head and Compound Eyes of the *Bee*, showing the Ocelli *in situ* on one side (A), and displaced on the other (B). *a, a, a*, Stemmata. *b, b*, Antennæ.

which come to it from a particular direction. In many insects each composite eye forms a hemispherical protuberance upon the side of the head, which, when examined by the

709. Compound Eyes — Number of Facets.— The eyes of many of the articulate animals are constructed upon the compound type, that is, the visual organs are made up of an aggregation of single eyes placed upon each side of the head, each one of which is a complete visual instrument, but can receive and bring to a focus only those rays of light

FIG. 355.

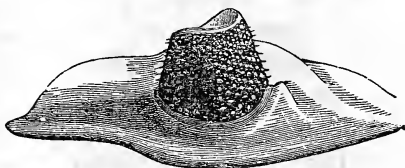


A, Section of the Eye of *Melolontha Vulgaris* (Cockchaffer). B, A portion more highly Magnified. *a*, Facets of the Cornea. *b*, Transparent Pyramids surrounded with Pigment. *c*, Fibers of the Optic Nerve. *d*, Trunk of the Optic Nerve.

What are the pigmentary spots? 709. What are compound eyes? What sub-kingdom do they characterize? How does the eye appear on many insects?

magnifying glass, is found to be made up of a vast number of facets, which are generally hexagonal. In the common house fly there are 4,000 in each eye, in the dragon fly 24,000, and in one species of the beetle 25,000. Each one of these facets is found to be the end of a little eye, the frustum of a slender pyramid standing by its apex on a bulbous expansion of the optic nerve. The interior of this pyramid is filled with a trans-

FIG. 356.



Eye of Fossil Tribolite constructed on the same plan.

parent substance which represents the vitreous humor, while between the frustra is found the black pigment. Both surfaces of these facets are found to be convex, and it has been calculated that the focus of these lenses would be at a point just at the extremity of the pyramid where it joins the optic nerve. And since the rays of light entering one of these facets can not enter the other on account of the black pigment intervening between them, the range of vision to the insect would necessarily be very limited were it not for their enormous multiplication, by which in reality a separate eye is provided for every point to be viewed, thus giving to the insect as perfect an apparatus of vision as we have, although immovably fixed on the body.

710. *Stemmata*.—Besides the composite eyes, insects usually have a small number of simple eyes situated upon the top of the head, called *Stemmata*. If they are covered with paint, the movements of the insect are constantly upward.

711. *Other Articulates*.—A few insects that live in dark places have no eyes. Some Crustaceans have compound eyes without facets, and others with them. Some Annelids have eyes, others none. The Rotatoria have vision, but the Hel-

What number of facets are there in the house fly and in the dragon fly? Give the anatomy of each facet or pyramid. 710. What other organs of vision besides compound eyes do insects have? If the *stemmata* are removed what is the result? 711. What of the eyes of articulates?

minths are without eyes. Among Arachnida (spiders) the eyes bear a near relation to the vertebrate type of eyes. Their number is much less than among the other articulata, seldom more than eight, and are to be compared more with stemmata than with compound eyes. Sometimes these are collected into one mass upon the second segment of the body, and sometimes they are arranged symmetrically upon the median line.

712. Eyes of Molluscs.—The organs of vision in the Acephala are numerous, rising as high as forty in the genus Pinna, where they are placed in the mantle. The Cephalopora have generally two eyes. In the Cephalopoda the eyes are disproportionately large, and possess nearly all the parts found in the eyes of vertebrates.

713. Eyes of Radiates.—The Polypi show a sensibility to light, but no eyes have been discovered in them. The Acalephæ seem to have the sense of vision, and Agassiz seems to have ascertained the presence of an organ for this purpose in some of them. It is more doubtful in respect to the Echinoderms.

What eyes have spiders? 712. What are the eyes of molluscs? 713. What is said of the organs of vision among radiates?

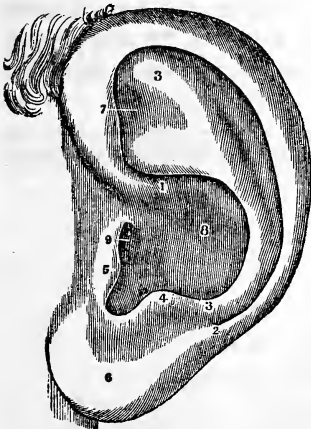
THE SENSE OF HEARING.

DEFINITIONS AND DESCRIPTIONS.

714. **Parts of the Ear.**—The organ of hearing is made up of three distinct portions: the Pinna or external ear, the Tympanum or middle ear, and the Labyrinth or internal ear.

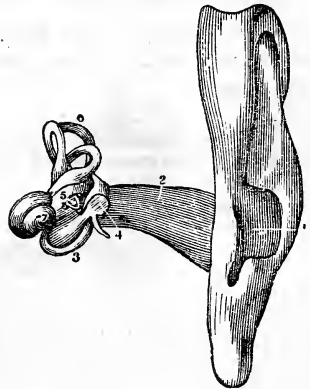
715. **The Pinna.**—The Pinna, commonly known as the Ear, is a cartilaginous plate with numerous irregularities upon its surface, and having upon it a few muscular fibers, which

FIG. 357.



A View of the Left Ear in its Natural State. 1, 2, The origin and termination of the Helix. 3, The Anti-Helix. 4, The Anti-Tragus. 5, The Tragus. 6, The Lobus of the External Ear. 7, Points to the Scapha, and is on the front and top of the Pinna. 8, The Concha. 9, The Meatus Auditorius Externus.

FIG. 358.



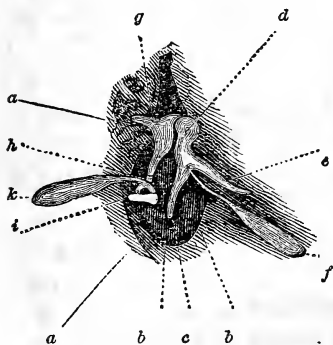
An Anterior View of the External Ear, as well as of the Meatus Auditorius, Labyrinth, etc. 1, The Opening into the Ear at the bottom of the Concha. 2, The Meatus Auditorius Externus or Cartilaginous Canal. 3, The Membrana Tympani stretched upon its Ring. 4, The Malleus. 5, The Stapes. 6, The Labyrinth.

are in fact rudimentary muscles, 5 in number. In some men they have been so fully developed that the ears could be moved by their action, while among quadrupeds there are but few that do not possess this power. The Pinna somewhat resembles a funnel, forming at its base an irregular tube called the Auditory Canal, about half an inch in diameter and an inch in length, which terminates with the Tympanum. A few stiff hairs are found upon the sides of this canal, and in the lining membrane some glands, which secrete the wax of the ear.

716. The Tympanum.—*Membrana Tympani*.—Little Bones of the Ear.—The Tympanum is an irregular cavity located in the petrous portion of the Temporal bone, measuring rather more than one half inch in its longest diameter. At the point where the Auditory Canal joins

the Tympanum, the *Membrana Tympani* is found, which is simply an impervious membrane stretched between the two cavities, dipping inwards at an angle of forty-five degrees. To this membrane are attached three muscles for the purpose of rendering this membrane lax or tense, as may be

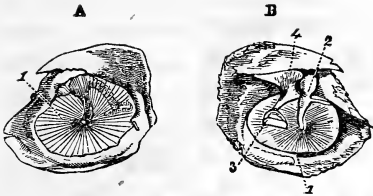
FIG. 359.



View of the Cavity of the Tympanum, the Ossicula Auditus, and their Muscles, magnified. *a, a*, Cavity of the Tympanum. *b*, *Membrana Tympani*, or rather the osseous circle to which it is attached. *c*, Handle of the Malleus, resting on the middle of the *Membrana Tympani*. *d*, Head of the Malleus articulating with the Incus. *e*, Long Handle of the Malleus, passing into the Glenoidal Fissure; the Anterior Muscle of the Malleus is attached to it. *f*, Internal Muscle of the Malleus. *g*, Anvil. *h*, Lenticular Bone. *i*, Stapes. *k*, Muscular Stapedius.

Can the ear ever be moved? How many rudimentary muscles are placed on it? 716. What is the tympanum? Describe the *membrana tympani*.

FIG. 360.



Membrana Tympani from the Outer (A), and from the Inner (B) Sides. 1, Membrana Tympani. 2, Malleus. 3, Stapes. 4, Incus.

FIG. 361.



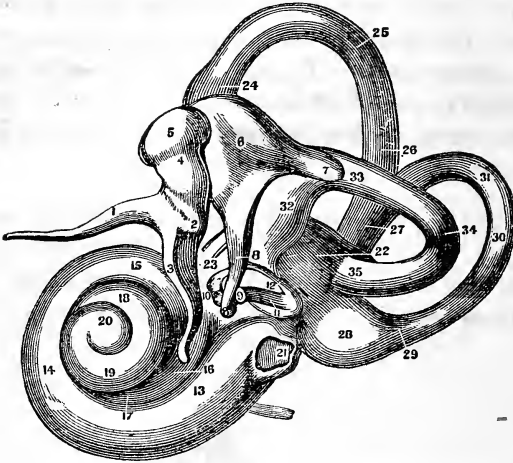
Small Bones of the Ear. *a*, The Malleus. *b*, The Incus. *c*, The Lenticular Bone. *d*, The Stapes.

required. This cavity contains the “little bones of hearing,” as they are sometimes called. These are the Malleus, a hammer,—the Incus, an anvil,—and the Stapes, a stirrup, because they somewhat resemble these instruments. The Malleus lies directly against the drum of the ear (Membrana Tympani), its opposite side connecting with the Incus, which is in connection with the end of the Stapes, thus forming a continuous chain of bones through the Tympanic Cavity. In the walls of the Tympanum are no less than ten openings, the most important of which are, one downwards into the Pharynx known as the Eustachian Tube, another into the Labyrinth, which is closed by the foot of the Stapes, and another outwards to the External Ear.

717. Labyrinth.—Cochlea.—Semicircular Canals—Perilymph.—Vestibule.—The Internal Ear is called a Labyrinth because of its very complicated structure and functions. (Fig. 362, p. 392.) It mainly consists of a series of semicircular canals and cavities, of which some are made up of cartilage, and others of bone. The canals are composed of bone, three in number, and their respective planes arranged at right angles to each other. They contain the nerves of hearing and other substances, which facilitate the transmission of sound. One of these portions is named the Cochlea, because

What are the names of the bones of the ear? How many openings are there in the tympanum? 717. What is the labyrinth? Of what is it mainly made up?

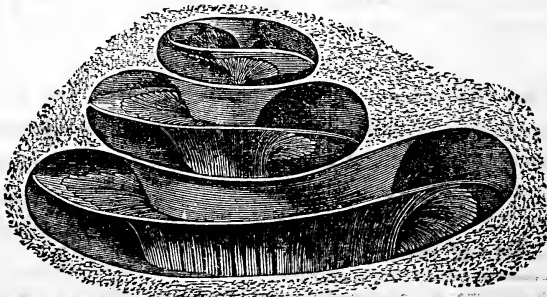
FIG. 362.



A View of the Labyrinth and Tympanum of the Ear, with the Bones in Situ, highly magnified. 1, Processus Longus of the Malleus. 2, Its Processus Brevis. 3, Its Manubrium. 4, Its Neck. 5, Its Head. 6, Body of the Incus. 7, Its Processus Brevis. 8, 8, Its Processus Longus, with the little head for articulating with the Stapes. 9, The Head of the Stapes. 10, Its Anterior Crus. 11, Its Posterior Crus. 12, Its Base. 13, 14, 15, The first turn of the Cochlea. 16, 17, 18, Its second turn. 19, Its half turn. 20, The Cupola. 21, The Fenestra Rotunda. 22, 23, The Vestibule. 24, 25, 26, Anterior Semicircular Canal. 27, Its junction with the Posterior Canal. 28, 29, 30, 31, The Posterior Semicircular Canal. 32, 33, 34, 35, The External Semicircular Canal. The Enlargements on these Canals are called Ampullæ.

it resembles a snail shell, and some of the others semicircular canals, because they are tubes containing fluid called Peri-

FIG. 363.

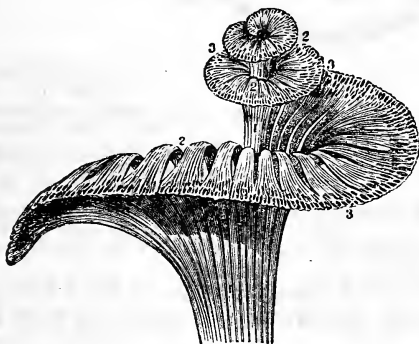


Cochlea without the Nerve.

lymph and nerve fiber, which take the general direction of a semicircle. Of these cavities, however, the cochlea is not filled with the perilymph, but contains the finest subdivisions of the auditory nerve. Besides the cochlea and semicircular canals there is a small three-cornered cavity called the Vestibule, into which the five openings of the semicircular canals enter.

718. Auditory Nerve.—The nerve of hearing belongs to the eighth pair of Cranial nerves. It divides into two branches just before it enters the ear, one of which is called the cochlear branch, because it is sent to the cochlea, and an-

FIG. 364.



Auditory Nerve taken out of the Cochlea. 1, 1, 1, Trunk of the Nerve. 2, 2, Its filaments in the Zona Ossea of the Lamina Spiralis. 3, 3, Its Anastomoses in the Zona Vesicularis.

other the vestibular, since it enters the vestibule, a portion of the labyrinth. Besides this a branch of the facial nerve enters the ear in company with the auditory.

719. Location of the Internal Ear.—In man and all the higher animals there are two separate organs of hearing,

Describe the cochlea. What are the semicircular canals? What are they filled with? 718. What is the nerve of hearing? 719. In what bone is the ear located?

or an ear upon each side of the body, and no internal connection exists between them, so that one may be injured or destroyed while the other performs its office. In fact, the internal ear is protected by the hardest bone (the temporal) in the body, and is inclosed in a bony sac to which the only opening of any considerable size is that of the auditory canal.

FUNCTIONS OF THE EAR.

720. Functions of the Pinna.—The object of the pinna is to convey sound to the auditory canal. This it does by conduction and convection; that is, it acts as a funnel to collect the vibrations of air and transmit them to the auditory canal, and also conducts sounds by means of its own substance in the same manner as a stick of timber conveys the sound made by the scratching of a pin to its opposite extremity with great distinctness. Hence the use of the external ear is to collect sounds from as large a surface as possible, and concentrate them at the small end of a funnel, so as to increase somewhat their intensity. The probable design of the ridges and furrows upon the pinna is to give a greater exposed surface to it as well as to receive vibrations more accurately which come in various directions.

721. Use of the Auditory Canal.—The use of the auditory canal is to give greater intensity to the sounds collected by the external ear. This can be illustrated by placing a long tube close to the ear, while another person speaks at the other extremity. The voice will be greatly increased in intensity, because every vibration is transmitted to the ear, and none are dissipated upon the air or surrounding substances. The auditory canal performs the same office, although in a less degree than in the above experiment. This canal also exists

Is there any communication between the two ears? 720. What is the object of the pinna? How does it convey sound to the internal ear? Why is the pinna of such an uneven surface? 721. Of what service is the auditory canal? How may its use be illustrated?

for protection to the membrana tympani and the delicate organs of the ear, which must be placed within the head to such a distance that no harm could come to them from external violence.

722. Function of Membrana Tympani—Use of the “Little Bones.”—The membrana tympani is a very thin and elastic membrane, not half an inch in diameter, which is designed to receive all the vibrations of the air falling upon it. On this account it is stretched directly across the auditory canal, and is so arranged that by means of muscles it may be rendered more or less tense, so that if it is desired to catch a very faint sound, the drum may be made so sensitive as to catch the slightest vibration. The sound received by the drum of the ear is transmitted to the auditory nerve by means of the chain of bones already mentioned, the broad side of the malleus resting directly against the drum, and the broad end of the stapes closing the opening in the semicircular canals which contain the nerve of hearing. The use of this arrangement seems to be to catch all the vibrations of the drum, and instead of allowing them to expend themselves upon the air in the tympanum, to transmit them directly to the auditory nerve. The use of the cavity of the tympanum seems to be to allow a free vibration of the membrane of the drum. Another reason for the large size of the tympanum is to prevent the conveyance of sound to any other part of the ear but the semicircular canals, and that by means of the chain of little bones. And in order to convey the sound only to the nerve of hearing the stapes joins on to the canal, not by a solid articulation, but simply by cartilage, so that none of the vibrations can be conveyed to the walls of the canals, but all to the nerve.

723. Function of Eustachian Tube.—The design of the

What does this canal protect? 722. What is the function of the membrana tympani? Of what use are the “little bones?” What service is rendered by the tympanum? How does the stapes unite with the canal?

Eustachian tube is evidently to allow of equal atmospheric pressure upon both sides of the membrana tympani. For were the air in the tympanum closely confined, the atmosphere, varying as it does in density, would sometimes create such a pressure on the drum that all vibrations would be indistinctly conveyed to the brain. This is the same arrangement that is found in bass and tenor drums used for musical instruments, a small orifice always being necessary to give free access to the air. Hence, when we have a cold, or especially a sore throat, where the mucous membrane is inflamed, we often find hearing difficult, because the lining membrane of the Eustachian tube is so much swollen that air can not pass through. Also when the same condition prevails we can, by swallowing the small amount of saliva in the mouth with considerable force, drive so much air into the tympanum that a sense of fullness occurs in the ear, which continues until the air has found some means of escape.

724. Functions of the Internal Ear.—The uses of all the parts belonging to the internal ear are not perfectly understood. Probably, however, the labyrinth and cochlea serve to give as great expansion as possible to the nerve in the small space provided for it. And the use of the fluid filling the labyrinth is to secure all the vibrations coming in through the bones of hearing, and give them greater intensity. Some experiments worked out by Muller, a German physiologist, throw considerable light on the subject. He found that sounds passing directly into water from the air lose considerable of their intensity; but if a tense membrane is placed between the two, greater intensity is produced. The intensity is also greatly increased when to this membrane is attached a small solid body which communicates with the water alone. This seems to show why the drum receives all the sound

723. What is the use of the Eustachian tube? In what instruments of music is there a similar arrangement? Why does partial deafness sometimes accompany a cold? 724. What is said of the functions of the internal ear? Relate the experiments made by Muller.

rather than some other part of the ear, and also the value of the three small bones of the ear, at one extremity fastened to the drum and at the other by cartilages to the semicircular canals. Other experiments also showed that a solid body of the form of the stapes alone was the best to communicate with the auditory nerve.

725. **Function of the Cochlea and Semicircular Canals.**—It has been thought by some that the cochlea enables one to determine the pitch of sound, since animals which possess the fullest development of this organ have the largest range of voice. Another speculation is, that the semicircular canals aid in the determination of the direction from which sounds come, since in animals where they exist, they are always placed at right angles to each other.

725 *a*. **Three Physical Properties of Sound.**—The three physical peculiarities of sound are intensity or loudness, pitch or length of the waves, and quality, or the difference between the same note on a flute and violin, although equal in intensity and pitch. And a theory has been proposed, substantiated by many facts, that the membrana tympani enables us to determine the intensity, the cochlea the pitch, and the semicircular canals the quality of sound.

THE SENSE OF HEARING IN ANIMALS.

726. **External Ears—Semicircular Canals—Cochlea—Os Quadratum.**—All mammals, as a general rule, have external ears. These, in some animals, like the bat, are enormously developed in proportion to the dimensions of the body. Besides, in several genera they can be turned in any direction the animal may choose. In man the ear consists of but one

725. What suggestion has been made of the use of the cochlea and semicircular canals?
725 *a*. What are the three physical peculiarities of sound? 726. What mammals have external ears? What is said of them in the bat? How many pieces has the pinna in most animals?

piece, while in the other mammalia it consists of three. But the most important part of this organ, the labyrinth, agrees in its structure throughout the whole class. The greatest variation that exists is in the semicircular canals and cochlea. In the cat the canals form the segment of a circle, while in the goat they furnish a portion of an ellipse, and in the horse a parabolic curve. The cochlea varies in the number of its coils. In the whale and dolphin it makes but one and a half turns; in man two and a half; in the ornithorynchus half a coil much resembling that of a bird; while in the squirrel it makes nearly four turns. No physiological effect of these variations has as yet been given. In man and the apes the whole cavity of the tympanum is concealed in a portion of the temporal bone, but in all other mammals we find a peculiar tympanic bone which varies exceedingly in the different classes.

727. *Ear of Birds.*—There are but few birds which have any thing like an external ear. One species of owl, however, has a membranous concentric fold which can be used as a valve. The cochlea has the form of an obtuse cone, which at its extremity swells into an oval tubercle. The tympanic cavity communicates with cavities in the cranial bones, which greatly increases the resonance of sound, in the same manner as the sounding-board in the piano, or the main body of a violin or violincello.

728. *Hearing in Reptiles.*—Although reptiles present a more imperfect form of the organ of hearing than mammals or birds yet they possess the tympanum, a membrana tympani, and a chain of ossicles or little bones. Also a cochlea is found, which is most fully developed in crocodiles and formed almost as in birds.

How do the canals differ in different animals? What variation in the cochlea? What is the os quadratum? 727. What bird has external ears? What is said of the cochlea in birds? What does the tympanum communicate with? What is the use of this arrangement? 728. What is said of the organs of hearing in reptiles?

729. *Hearing of Fishes.*—Among the lowest order of fishes the organ of hearing is simply a sac, which is full of a fluid that contains small bones or bits of bones called otoliths, and the auditory nerve is distributed upon its walls. In almost all fishes there is a more or less perfect form of the semi-circular canals. In some fishes the swimming bladder extends to membranous spaces in the cranium which are in connection with an auditory apparatus.

730. *Articulates.*—Among the Crustaceans hearing has been observed only among the Decapods. The sense exists in the Arachnoids, but no organ has been found. The same is true of Insects, Annelids, and Helminths.

731. *Molluscs.*—Hearing has been ascertained in Lamelli-branchiata. In Cephalophora it is of a low grade: but an auditory nerve and organs exist in the Cephalopoda.

732. *Radiates.*—The organ of hearing exists in the Polypi and perhaps the Acalephs, but has not been discovered in the other Radiates.

SENSE OF TOUCH.

DEFINITIONS AND DESCRIPTIONS.

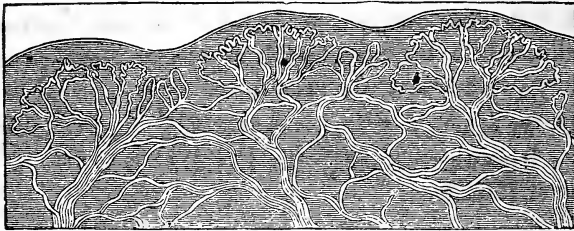
733. *Location of the Sense of Touch.*—The organ of touch, with the exception of the upper surface of the tongue, is the skin. This in some parts is much more sensitive than in

729. Do fishes have the regular organs of hearing? What organs do they have in a rudimentary state? 730. What apparatus of hearing do articulates possess? Do they seem to hear sounds? 731-732. What is said of the sense of sound in molluscs and radiates? 733. Where are the organs of touch located?

others, since some portions of the skin are more fully crowded with nerve fibers than others. We are conscious of resistance if we place a substance in contact with any part of the body; and although we are able with the tips of the fingers to tell, whether a body, which is pressed on them, is circular or rectangular, yet we can not with certainty decide the same thing, if the substance be pressed upon any other part of the body.

734. The Direct Instruments of Touch.—The direct instruments of sensation are minute loops of nerve fibers from the posterior roots of the Spinal Column, lying in the true

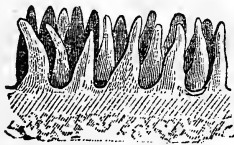
FIG. 365.



Nerves of Sensation at the Extremity of the Human Thumb.

skin, which are covered only by the Epidermis, as is seen in Fig. 365. These nerves of sensation are never known to terminate in a free extremity, but always in loops; and in the hand and foot are associated with the Pacinian Corpuscles, described under the nervous system.

FIG. 366.



Papillæ of the Palm of the Hand.

735. Papillæ.—Those parts of the skin which are the most sensitive, are covered with minute projections called Papillæ, which seem to be mere elevations beyond the general surface of the

What is said of the whole cutaneous surface? 734. What are the immediate instruments of touch? How do the sensitive nerves always terminate? 735. Describe the papillæ.

skin, in which are found the loop of a nerve, and a blood-vessel with some cellular tissue. The main use of them seems to be to place the nerve in such a position, that it will be most easily impressed with whatever external substances it may be brought into contact.

FUNCTIONS.

736. *The Superficial Parts of the Body most abundantly Supplied with Nerves.*—The parts of the body lying deep beneath the skin, are but sparingly supplied with nerves of sensation, which is a great comfort to those unfortunate persons who are subjected to surgical operations, since the most painful part is in cutting through the skin, which is the quickest part of the operation. This, however, is the case only when the deep parts are in health (including the bones); for if any of these parts, and especially the bones and ligaments, are diseased, they constitute a source of the greatest pain. The necessity of this arrangement is obvious from the protection which the surface of the body requires from violence and heat. Were it not for these *body-guards*, we by our other senses should seldom know when friction or heat was consuming the skin, nor when cold was destroying its vitality.

737. *Value of this Sense to the Blind.*—To those deprived of the sense of vision, this sense is of great value, since it is by this only that they are enabled to pursue any labor, or instruct and please themselves by raised alphabets, or play upon musical instruments. And it is interesting, not to say wonderful, to see what accuracy is acquired by the blind in detecting true from spurious coins, or in distinguishing the quality of cloth by feeling alone. It is said on good author-

What is the function of the papillæ? 736. Why are the superficial parts of the body the most abundantly supplied with sensitive nerves? Why does the skin need sensibility? 737. What is said of the value of this sense to the blind? What examples are mentioned as illustrating its extreme acuteness in the blind?

ity, that one blind man became a botanist, another a conchologist, and another a land surveyor, simply by the aid of touch.

738. *Effect of Habit on Location of Sensation.*—Habit has a wonderful power in the location of sensations on the skin. Thus it is frequently the case, after an amputation of a limb, that the patient declares that he feels pain in the removed portion. This is owing to some irritation in a fiber or fibers of the remaining nerve trunk, which were originally sent to the supposed seat of the pain, and from habit the sufferer locates it in the removed part. Also after the Taliacotian operation—which consists in making a new nose from the skin of the forehead,—if the nose itches, the patient scratches the forehead as the seat of the irritation.

739. *Insensibility produced by a long continued Action of some painful Stimulus.*—It is sometimes the case that the nerves are rendered insensible by the moderate but long continued action of some painful stimulus. A complete insensibility of the skin may be produced, so that the severest surgical operations may be performed without pain, by the application of snow and salt mixed in equal portions. Heat will also do the same thing, as shown by the following example. “A traveling man one winter’s evening laid himself down upon the platform of a lime kiln, placing his feet, probably benumbed by the cold, upon the heap of stones newly put on to burn through the night. Sleep overcame him in this situation: the fire gradually rising and increasing, until it ignited the stones upon which his feet were placed. Lulled by the warmth the man slept on; the fire increased until it burned one foot and part of the leg above the ankle entirely off, consuming that part so effectually that a cinder-like fragment was alone remaining, and still the wretch slept on, and in this state was found by the kiln man in the morn-

738. What effect has habit upon localizing our sensations? 739. How may insensibility be sometimes brought about? What wonderful example?

ing. Insensible to any pain, and ignorant of his misfortune, he attempted to rise and resume his journey, but missing his shoe, requested to have it found: and when he was raised, putting his burnt limb to the ground to support his body, the extremity of his leg bone—the tibia—crumbled into fragments, having been calcined into lime. Still he expressed no sense of pain, and probably experienced none, from the gradual operation of the fire, and his own torpidity during the hours his foot was consuming.”

THE SENSE OF TOUCH IN ANIMALS.

740. “It is probable that among the lower animals the proportion of intuitive perceptions is much greater than in man; whilst on the other hand his power of acquiring perceptions is much greater than theirs.”

741. Touch in Mammals.—Cat, Rabbit, Elephant, Bat.—Among Mammals touch ordinarily depends on little projections known as papillæ, which contain a loop of a sensitive nerve. In man this structure is principally found in the tips of the fingers, but in the Monkey it is found in both the hands and feet. In a majority of mammals the surface of the nose, upper lip, and the vibrissæ or whiskers, as seen on the face of the cat, are organs adapted to the sense of touch. Cats are unable to catch mice when these whiskers are removed, and Rabbits without the assistance of their eyes can by means of these hairs find an outlet in a very narrow passage. In the Elephant this sense has its seat at the extremity of the proboscis. The wing of the Bat possesses an extraordinary sensitive power. It is said that this animal is

740. What is said of the intuitive perceptions of the lower animals? 741. Where is the sense of touch most perfectly developed in animals? Of what use are the whiskers of the cat and rabbit? Where is the sense of touch in the elephant?

able to fly through perfectly dark and irregular narrow passages, and avoid all obstructions simply by the delicate sensibility of its membranous wings.

742. *Touch in Birds.*—The only portions of the skin in Birds, on which tactile papillæ exist, are found on the under surface of the foot, and the web of the web-footed birds. The bill of the Duck seems also to subserve the sense of touch, upon the inside of which the skin is soft, and has many branches of the fifth pair of nerves distributed to it.

743. *Touch of Reptiles.*—The sense of touch seems to exist in Reptiles, though the prominent use of the skin is to afford a protection to the body. It is quite probable that the acuteness of this sense in these animals is no greater than what is derived to the Horse through the hoof, or to a man through a stick or rod in the hand.

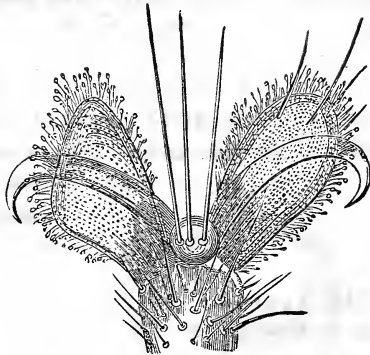
744. *Touch of Fishes.*—Fishes probably have a still more imperfect sense of touch than Reptiles. It is possible that the lips may give an imperfect idea of the form of external objects; but the surface of the body, covered as it is with scales and a thick mucous secretion, can be of no service in this sense. A few fishes have hair-like appendages about the head, which put them in a condition to be acquainted with the presence of external objects, though they are not by any means organs of active touch.

745. *Touch of Articulates.*—This sense is well developed in all the Articulates, and shows itself especially in the antennæ, the palpi, and feet; and though these organs have a tough, hair-like consistence, yet they are efficient instru-

Where in the bat? 742. Where are papillæ found in birds? What answers the purpose of papillæ in the duck? 743. What is said of the sense of touch in reptiles? 744. Where is the sense of touch located in fishes? 745. Describe the sense of touch in articulates.

ments of sensation. "For just as a blind man judges of the proximity and character of objects by the impressions communicated to his hand by the contact of his cane, with which he examines them, so may an insect or crustacean receive sensory impressions from the nerves distributed to the basal joints of their long antennæ, although the organs themselves may be as insensible (or rather as unimpressible) as the stick."

FIG. 367.



A Foot of a Fly.

746. Touch of Molluscs.—The sense of touch in this group is well developed. In some of the orders the organs are from two to four contractile tentacles situated upon the head, or the anterior part of the back." "With some Gasteropods these tentacles are hollow and button-like at their extremity, and can be inverted like the finger of a glove."

747. Touch of Radiates.—"The sense of touch is well developed among the Echinoderms." It exists here and among other Radiates in tentacles or feelers. Besides this, other individual Radiates seem to possess a sensitiveness of the whole surface of the body, though nerves can not be the agents which secure this sense to them.

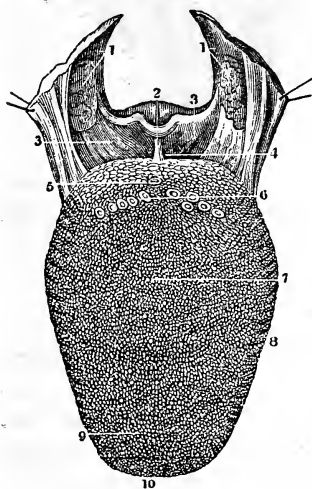
Is it by an active touch that this sensation is gained by articulates? 746. Describe touch in molluscs. 747. What is the touch of radiates?

SENSE OF TASTE.

DEFINITIONS AND DESCRIPTIONS.

748. Anatomy of the Tongue.—The tongue is preëminently the organ of taste. Its principal part is made up of muscular fibers which run in various directions, although they run in similar directions upon the opposite halves of this organ. The tongue is covered with a thick mucous membrane, which contains a large number of papillæ similar to those of the skin, which are of three kinds, the Filiform, Fungiform, and Circumvallate.

FIG. 368.



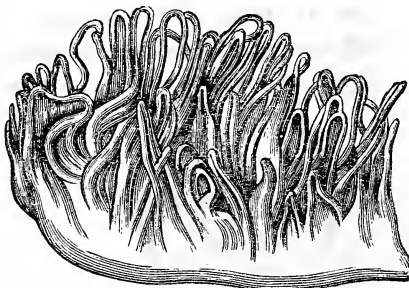
Front View of the Upper Surface of the Tongue, as well as the Palatine Arch. 1, 1, Posterior Lateral Half Arches, with the Palato-Pharyngeal Muscles and Tonsils. 2, Epiglottic Cartilage, seen from before. 3, 3, Ligament and Mucous Membrane, extending from the root of the tongue to the base of the Epiglottic Cartilage. 4, One of the Pouches on the Side of the Posterior Frænum, in which food sometimes lodges. 5, Foramen Cæcum. 6, Papillæ Capitatae sen Maximæ. 7, The white point at the end of the line, and all like it, are the Papillæ Fungiformes. 8, Side of the Tongue and Rugæ Transversæ of Albinus. 9, Papillæ Filiformes. 10, Point of the Tongue.

muscular fibers which run in various directions, although they run in similar directions upon the opposite halves of this organ. The tongue is covered with a thick mucous membrane, which contains a large number of papillæ similar to those of the skin, which are of three kinds, the Filiform, Fungiform, and Circumvallate. The filiform are from one thirty-sixth to one eighth of an inch long, of a conical shape, and are most abundant on the middle portion of the tongue. The fungiform are situated upon the tip and sides of the tongue, and are somewhat smaller than the filiform. The circumvallate are from six to twelve in number, and are arranged upon the base of the tongue in the form of the letter V, the apex pointing downwards. They consist of a central round papilla flat-

748. What is the organ of taste? Of what is it made up, and with what is it covered? Name the three kinds of papillæ. Describe the filiform, fungiform, and circumvallate.

tened at the end, one twenty-fourth to one twelfth of an inch in diameter, with a lower uniform wall closely surrounding the papilla. More nerves are distributed to the circumvallate than to either of the other forms of papillæ. At its lower or posterior extremity the tongue is attached to the os hyoides, and at its lower front portion to the lower jaw by the frænum or bridle of the tongue; so that it is left free to move either backwards or forwards by the contraction of the appropriate muscles.

FIG. 369.



One of the smallest Papillæ of the Tongue highly Magnified.

749. Blood-Vessels of this Organ.—A great quantity of blood-vessels are distributed to this organ, as can be seen by looking at the under side of it, as well as by the free flow of blood when it is wounded.

750. Nerves of Taste.—Of nerves there are no less than three large branches supplied to the tongue from the cranial group: the gustatory or proper nerve of taste, a branch of the fifth pair which is distributed to the papillæ; the glosso-pharyngeal distributed to the mucous membrane, being both a nerve of motion and sensation; and the hypoglossal distributed to the muscles, being preëminently a nerve of motion.

F U N C T I O N S .

751. Use of the Numerous Muscular Fibers in the Tongue.—To effect the numerous movements of the tongue in

Which kind receive the most nerves? To what is the tongue attached by its lower extremity? 749. What proportion of blood is sent to this organ? 750. How many nerves are sent to the tongue, and what are they?

mastication, swallowing, tasting, articulation, etc., it is necessary that the muscular fibers should run in various directions. That, however, which is commonly known as the tongue is only the tip of it, while the largest portion lies in the front and lower portion of the pharynx, where most of the muscular actions are performed.

752. Use of the Papillæ.—The papillæ of the tongue, as those of the skin, are constructed for the purpose of giving as much surface of nerve to be exposed as possible, leaving it mostly in the form of a loop. The filiform papillæ are not the seat of the sense of taste or touch, but are analogous to the lingual spines of lower animals (which gives such roughness to their tongues), which aid in mastication and protection of the tongue. As the sense of touch is most acute at the tip of the tongue, it is supposed that the fungiform papillæ are the instruments of touch to the tongue; and as we acquire the sense of taste more at the base than at the tip of the tongue, and as the nerves are more abundant and finest at the circumvallate papillæ, these probably administer mainly to the sense of taste.

753. Object of this Sense.—The main use of this sense is to direct us in the choice of proper articles of food, and by this means to excite the flow of saliva and mucus, to aid in digesting food. In man, however, this sense would be an unsafe guide, since this alone can not aid us to distinguish wholesome from poisonous food, although many of the lower animals seem able to make such a distinction by this sense alone.

754. Effect of Education on Taste.—Taste is made wonderfully acute by education. Epicures are able to tell the manner in which game was killed, the spices used in cooking it, and the length of time since it was killed, when eating it.

751. Why are there so many muscular fibers in the tongue? Where does the larger portion of this organ lie? 752. Of what use are the papillæ? What sensation is gained by the filiform papillæ? In what papillæ does the sense of taste mainly exist? 753. What is the use of this sense? Is it alone a safe guide for man? 754. What effect has education upon taste? Give instances.

Wine tasters can readily give differences in the age, growth of the grape, and the purity of wines, that to ordinary observers are imperceptible.

755. Taste as Influenced by Smell.—Taste, as to some substances, is dependent on the sense of smell. Thus, with the eyes and nostrils closed, if an aromatic or spicy substance be chewed it is impossible to say what the substance is, except that it is pungent, although it may be one with which the person is well acquainted. Yet smell does not aid us in determining the taste of acids, alkalies, or salts.

756. After-Tastes.—An important point connected with this sense is that known as after-tastes. Thus, frequently after eating sweet substances a bitter taste is left in the mouth, and when bitter substances have been tasted a pleasant and sweet taste is left in the mouth. This subject is a matter of great importance in the art of cookery.

THE SENSE OF TASTE IN ANIMALS.

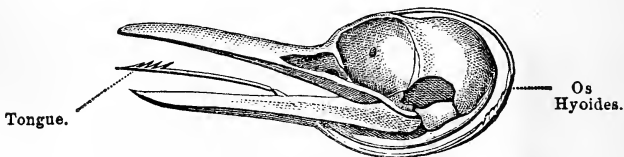
757. Use of the Conical Papillæ.—This sense is in all animals confined to the tongue and inner surface of the mouth. The sensation received from the sapid body is gained through the papillæ, which are present on the tongue and in general structure resemble those of the skin. There are probably four kinds in mammals, those upon the central part of the tongue often being conical, hard, and even horny, and those upon the back part fungiform, or soft and cup-shaped, as is seen in the tongue of the cat. The conical papillæ seem to act the part of a rasp, especially in the carnivorous animals, in order to remove all the particles of meat from bones. And

755. Give the connection between taste and smell. 756. What is said of after-tastes? 757. How many kinds of papillæ in most mammals? What are the uses of the conical papillæ to meat-eating animals? How powerful an instrument do these at times constitute?

so efficient are these that the skin of some of the more delicate animals is removed simply by the licking of the tongue of one of the more powerful carnivora.

758. *Tongue of Birds*—In the Woodpecker and Humming-Bird.—In birds this sense is very feeble, since the tongue is destitute of sensitive papillæ, and is often of a hard, horny consistence, designed probably more for the means of obtaining food than of judging of its quality. In some birds the tongue is furnished with one or more ossicles for the purpose of giving stability and strength to it. In woodpeckers the tongue is not only long, slender, and stout, but it is armed

FIG. 370.



Head of the Woodpecker.

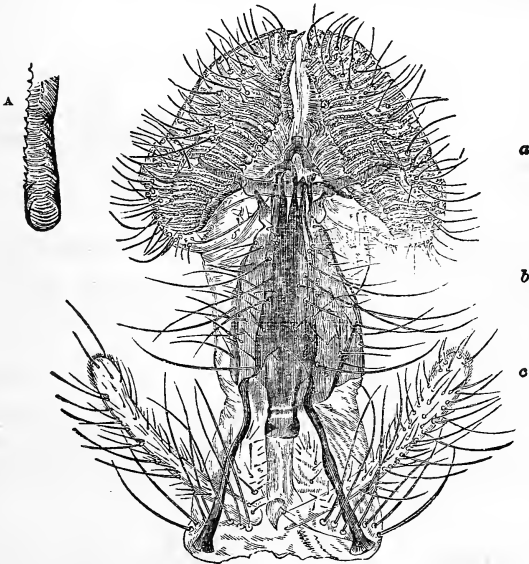
with appendages like barbs on either side, in order that it may be thrust into narrow crevices in trees, to pierce and hold insects upon which it lives. (See Fig. 370.) Humming-birds have tongues very slender and slit at the apex, so that both sides can be formed into a sort of tube by curving them together from the outside, in order that the bird may suck up the nectar of flowers. And in both of these birds the tongue can be extended for a long distance in front of the body.

759. *Tongue of Reptiles*—Chameleon.—The tongue of most of the class of reptiles seems to be constructed for other purposes than that of taste. Like that of birds, it is provided with one or more lingual (tongue) bones, and is desti-

758. How is it with the sense of taste in birds? Describe the tongue of the woodpecker. What is its use? What is the tongue of the humming-bird? How far can the tongue be protruded in either of these animals? 759. For what purpose is the tongue of reptiles?

tute generally of papillæ. In some of this class it is hardly perceptible, while in Serpents, Toads and the Chameleon, it is very long and capable of rapid motion. In Chameleons and Serpents, when the tongue is at rest, it lies in a kind of sheath at the base of the mouth. That of the latter is forked at its apex, while the former has a concave disk at its point covered by a viscid secretion, which, by the dexterity of the animal, can be thrown at once against the insects flying in the air, thus securing its food. In this case also the tongue seems longer than the body itself.

FIG. 371.



Tongue of Common Fly. *a*, Lobes of Lingula. *b*, Portion enclosing the Lancets formed by the Metamorphosis of the Maxilla. *c*, Maxillary Palpi. *A*, Portion of one of the Metamorphosed Tracheæ enlarged.

How does the chameleon obtain his insect food? 760. Have fishes any tongue, or the sense of taste? 761. How well is this organ developed in some of the lower animals? 762. Describe the shape of the nose. Of what is it principally composed?

760. This sense in fishes appears to be very feeble. "The part named tongue in them consists merely of the anterior extremity of the tongue-bone covered by mucous membrane." If fishes possess this sense, the palate rather than the tongue is probably its seat.

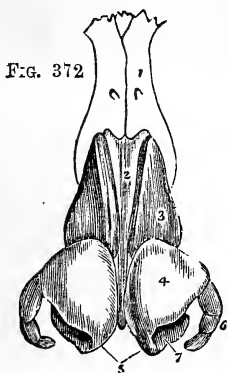
761. Invertebrates.—Taste, doubtless, exists in all the lower animals else how could they select their food? The seat of this sense is not always discoverable, as can be done in the Cephalopoda. But the sense exists in all, even in the Protozoa. Fig. 371 exhibits the tongue of the common fly, which is doubtless the seat of this sense.

SENSE OF SMELL.

DEFINITIONS AND DESCRIPTIONS.

762. Anatomy of the Nose.—The Nose which contains the organs of smelling, is a triangular pyramid placed upon the face, its apex connected with the forehead, and its base descending nearly to a level with the upper lip. It is principally made up of bone cartilage and integuments, having a

thin plate of bone (the vomer) and cartilage in the middle which run in a vertical direction, and divide the cavity into two portions called the nostrils. (Fig. 372.)



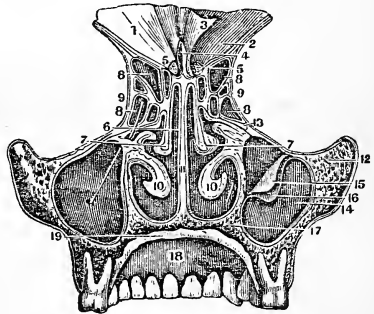
A View of the Cartilages of the Nose. 1, The Nasal Bones. 2, The Cartilaginous Septum. 3, The Lateral Cartilages. 4, The Alar Cartilages. 5, The Central portions of the Alar Cartilages which constitute the Columns. 6, The Appendices of the Alar Cartilage. 7, The Nostrils.

762 *a*. Use of the Bones.—Use of the Cartilages, and the Glands in Integuments.—The bones are the two nasal, which give form to the base of the nose, and furnish a firm attachment to the muscles. The cartilage is of use to give form to the nose, while its elasticity lessens the effects of injuries. The integument or skin is quite thick upon this organ, and aids the cartilage in giving form to it. It contains in its substance small glands, which secrete an oily matter to protect the nose from extremes of weather. These glands are liable to retain dust and other impurities in their orifices, forming the black specks on the nose.

763. Lined with Mucous Membrane.—The whole cavity of the nostrils is lined with mucous membrane, which is continuous with the lining membrane of the fauces or throat, with which the nostrils are in communication.

764. Cavities of the Nostrils.—Nerve of Smelling.—The cavities of the nostrils are very irregular, since upon their own outer sides are found the turbinal bones and a similar scroll-like portion from the ethmoid bone, for the purpose of giving as large a surface as possible for the expan-

FIG. 373.



A Vertical Section of the Middle Part of the Nasal Fossæ, giving a Posterior View of the Arrangement of the Ethmoidal Cells, etc. 1, Anterior Fossæ of the Cranium. 2, The same covered by the Dura Mater. 3, The Dura Mater turned up. 4, The Crista Galli of the Ethmoid Bone. 5, Its Cribriform Plate. 6, Its Nasal Lamella. 7, The Middle Spongy Bones. 8, The Ethmoidal Cells. 9, The Os Planum. 10, Inferior Spongy Bone. 11, The Vomer. 12, Superior Maxillary Bone. 13, Its Union with the Ethmoid. 14, Anterior Parietes of the Antrum Highmorianum, covered by its Membrane. 15, Its Fibrous Layer. 16, Its Mucous Membrane. 17, Palatine Process of the Superior Maxillary Bone. 18, Roof of the Mouth, covered by the Mucous Membrane. 19, Section of this Membrane. A Bristle is seen in the Orifice of the Antrum Highmorianum.

762 *a*. State the use of bone and cartilage in the composition of the nose. Of what service are the little glands in its skin? 763. What are the nostrils lined with? 764. Describe the cavities of the nostrils.

sion of the nerve of smell, and at the same time furnishing such an arrangement, that the air containing the odor can be readily drawn over it. This nerve is the Olfactory or first pair of cranial nerves, which, as soon as it reaches the nostrils, is divided into a great number of filaments, and these are distributed upon the mucous membrane—called Pituitary—already described. The fifth pair of cranial nerves also sends branches to this membrane, by means of which it is that sneezing is effected.

765. Smell under the Control of the Will.—The sense of smell is somewhat under the control of the will, since the air containing the odoriferous particles can be carried over the nostrils or rejected at pleasure, and it can also be cultivated to a great extent, although some persons are naturally more sensitive to odors than others. It is related that a gentleman who had a great antipathy to cats, could tell if there was one in the next room by smell alone. And the blind boy Mitchell always formed a favorable or unfavorable impression of a stranger by this sense.

THE SENSE OF SMELL IN ANIMALS.

766. The sense of smell is most perfectly developed in air-breathing animals, although many which live in the water, can distinguish odors or scents to a considerable distance.

767. Smell in Mammals.—In Mammalia the mucous membrane covering the turbinal bones is supplied with olfactive nerves. And in carnivorous animals, like the Lion and Tiger, these bones are split up into several laminae, giving them arborescent or tree-shaped forms, so that the membrane

Why are the turbinal bones placed here? What is the nerve of smelling? 765. To what extent is smell under the control of the will? What curious facts in this connection? 766. In what animals is this sense the most perfectly developed? 767. Among what mammals do we find this sense in the greatest perfection? What peculiarity in the turbinal bones in the lion?

may be expanded over as great a surface as possible. The cavities in the bones of the face and skull in these animals, as well as also the Horse and Deer, are very much developed, and all the mammalia, except the Whale tribe, are supplied with a turbinal bone, the cavities of which are lined by a membrane which greatly aids in the sense of smell. The sense of smell is also greatly developed in the timid grazing animals, so that they may in this way receive notice of the approach of their enemies and escape. For most quadrupeds give off a strong odor from their bodies, in the exhalations of the skin.

768. Smell in Birds.—A Nasal Gland.—Birds possess turbinal bones and a large nasal cavity, but it is doubted whether much of the power of discerning their prey depends on this sense, or whether it does not entirely depend on vision. For the olfactory nerve merely ramifies upon a part of the nasal cavity, the remaining portion being supplied with branches from the fifth pair. There is, however, a peculiar gland called the nasal, which serves the purpose of lubricating the pituitary (or mucous) membrane, which is probably necessary from the fact that so much air is constantly passing over the nostrils that the membrane would otherwise become dry and thus impair the sense of smell.

769. Smell in Reptiles.—Reptiles seem by their organization of very simple nasal cavities, to have their sense of smell feebly developed. A few only have bony or cartilaginous turbinal organs, and a portion only have the cavities lined by a pituitary membrane; and from the gormandizing habits of these animals, we see that the sense of smell could be of but little service to them.

770. Smell in Fishes.—Fishes possess a cavity lined by a

What bone is the whale tribe wanting in? How is the sense of smell in grazing animals? 768. How well developed are the organs of smell in birds? What is probably the case with regard to their powers of smell? What gland is furnished to them which possibly aids this sense? 769. What is said of this sense among reptiles? Is this sense of any great value to them?

pituitary membrane and furnished with olfactory nerves, which gives them a powerful organ of smell. This cavity, however, has no posterior orifice, its only opening being in front, and the water in it being continually kept in motion by the cilæ with which it is lined. In the sharks and rays there is a muscular appendage to keep the water in motion, so that Sir Richard Owen says these animals must actively scent (that is search for odoriferous impressions) as well as smell.

771. *Articulata*.—Crustaceans have the sense of smell, and the central ganglion sends off an olfactory nerve. The Arachnoids can smell without any discoverable organ. So also the Insects. Probably all of the *Articulata* have this sense, but perhaps without special organs.

772. *Molluscs*.—In Cephalopods olfactory organs are made out, but not in the other classes.

773. *Radiata*.—No distinct organs for this sense have been found in these animals. But the presumption is that it exists with or without special organs in them all.

Of the Protozoa the Infusoria clearly evince sensation and volition; but no nervous system has been discovered in them, and though it is quite manifest that they are sensible to the contact with objects and to light, yet there is no evidence that they have the sense of smell. Equally probable is it that it is wanting in the Rhizophoda.

HYGIENIC INFERENCES IN RESPECT TO THE SENSES.

774.—1. *Moderation in their Use Required*.—All the organs of sensation require to be moderately employed. If

770. How is it with the sense of smell in fishes? What peculiarity among the sharks and rays? 771. Have articulate animals the power of smelling? Have they the organs adapted to it? How is it probable that lobsters smell? 772. Can shell-fish smell? 773. What of animals lower in the scale?

the eye be used in too strong light, weakness or partial paralysis of the optic nerve may be produced; and if the ear receive too violent a sound, deafness may follow, and so with the other senses. Therefore care should be taken in the use of the senses, for when the function of one of the nerves of special sensation is gone, it is very rarely if ever restored.

775.—2. Sudden Extremes of Sensations to be Avoided.—With some of the senses, and especially that of vision, great care must be taken to avoid, if possible, sudden transitions. Next to very excessive use and mechanical violence, no greater trial can be given to the optic nerve than a sudden contact with powerful light. To a student this inference is of great value, and especially to those who would rise early and study by candle-light, before daybreak. This practice is often a source of confirmed weak eyes. One reason is, that during sleep the pupil is dilated, and when the eye is opened does not readily contract. This statement, however, is not an argument against early rising, which for other reasons has been shown to be healthy to the student. A good rule for students in sound health during the long nights of the year is to rise before daybreak, and after washing the eyes in pure cold water to take a good share of the exercise needed for the day. Then, after an early breakfast, when food and exercise are both obtained, he may be ready for a day's work of hard study by the congenial light of the sun. If, however, circumstances are such that we must study in the morning by lamp-light, we should commence and work moderately until the eye is accustomed to the light.

775. *a.*—3. Cleanliness of the Organs of Sensation Necessary.—Perfection of sensation requires that all the organs should be kept clean. The eye needs occasional washing, not

774. Why do the senses all require moderation in their use? What if a nerve of special sense is destroyed? 775. What is said of sudden extremes of sensation? Why should students especially avoid all extremes of light and darkness as far as possible? How does early rising affect the eyes? 775. *a.* How does cleanliness affect all the organs of the senses?

rubbing, with cold water; the ear not only needs the application of cold water, but occasionally the careful use of the ear-pick to remove the accumulations of wax which is gathered beyond the reach of ordinary washing. If the nostrils are buried by collections of snuff, how can we expect acuteness in the sense of smell?

776.—4. Senses Need Education.—The senses need education. No portions of the body show so well the good effects of discipline and practice as do the organs of sense. The power which, by training, can be acquired of distinguishing the faintest shades of color, the slightest discord between musical tones, and of the quality and flavor of food and drinks by the smell and taste, is so great as to astonish us.

777.—5. Is Taste a Proper Guide for the Appetite?—The question often arises whether the sense of taste can be considered a safe guide for the appetite. As it is natural, some maintain that it should always be gratified. But even if originally safe to follow, how often has it been perverted by extravagant diet, and is at the time in a morbid condition from a perverted state of the body? If such be the case, we should be on our guard against indulging peculiar appetites, or strange tastes. But in some cases, of which the physician is the best judge, it may be safe to allow a reasonable indulgence in a desire for a peculiar article of food or drink.

778.—6. Our Senses Sometimes become Sources of Misery.—In such a world as this our senses, especially if exquisitely cultivated, often become inlets of keen suffering. Objects disgusting to the soul must necessarily obtrude themselves upon every one. Those who are afflicted with a dainty appetite and are very nice and particular as to their food, often suffer acutely; while he who has learned to eat only that he may live, instead of living only that he may eat, experiences

776. Do the senses show the good effect of education? 777. Is taste a sufficient guide for the appetite? What is said of peculiar appetites and tastes? 778. Do our senses ever give us pain? In what way does a cultivated taste often make us wretched?

gustatory enjoyment from the same food that turns the stomach of another. True, a taste for the fine arts must be cultivated, although the sensorium will thereby be subject to pain from discords in sounds, and incongruities in colors and forms. But in respect to diet, regimen and manners it is hazardous to cultivate the sensibilities till we become disgusted with almost every thing we meet, and make ourselves objects of ridicule for our peculiarities.

779.—7. A higher kind of Happiness than that derived from the Senses.—Finally, we ought to remember that enjoyment gained through the senses, is not the highest kind of happiness for man. Though it be all, or nearly so, which the brute can enjoy, yet the intellectual and moral powers of man demand of him the control of his sensual desires, and a love for that which is far higher and purer, For thus will all his faculties be engaged in their appropriate sphere, and keep bright till the end of life, and as its evening shadows steal upon him, they will find him not full of disease and low desires, but peaceful and happy, ready to make a change from bodily to spiritual realities, almost without a sigh and with exulting anticipations.

779. Is sensual happiness superseded by no higher enjoyment?

CHAPTER NINTH.

RELIGIOUS INFERENCES FROM ANATOMY AND PHYSIOLOGY.

780. Highest Use of Science.—The highest and most important use of all science, is its religious applications: since these are eternal, while all its secular bearings are only temporal.

781. Religious Value of Anatomy and Physiology.—Perhaps no sciences are so prolific of religious applications as anatomy and physiology. They bear especially and almost exclusively upon Natural Religion.

I. PROOFS OF THE EXISTENCE OF GOD.

782. The argument for a Deity from marks of design so obvious in nature, derives some of its most striking examples from anatomy and physiology.

783. The Eye.—The eye has often been quoted as a striking instance. Who can mistake its object? And when we examine its structure, we see how admirably adapted all the parts are—the coats, the media, and the nerve—to secure this object. And it is done far more perfectly than by the finest optical instrument of man's construction.

784. The Ear.—In the ear we have another example almost equally striking, except that the special object of some of its parts is not so obvious as in the eye.

785. Hands, Lungs, Heart, etc.—We might say the same of the hands and the feet, the lungs, the muscles, the

nerves and the heart. If design is not manifested in their construction, it is difficult to see how they could be manifested. The mechanical arrangements and operations of the different parts of the system teach the same lesson.

786. *Skeleton.—Spinal Column.*—Take the bones of the skeleton for an example. How admirably are these arranged as a solid framework, around which the soft parts of the system may be built up! The vertebral column is not a single straight tube, as our wisdom would probably think to be the safest and best as a protection to the spinal cord within, but it is made up of over thirty bones separated by an elastic substance, yet locked together and fastened by strong ligaments, so as in fact to be stronger than a single piece, and moreover it is made somewhat crooked, so that it will yield a little when jarred, and thus prevent the brain from being injured.

787. *Joints.*—The joints too, how admirably fitted for the manifold movements we need to make! How securely fastened together by numerous strong ligaments! How much more effectually lubricated by the synovial fluid than the most perfect engine of human construction! Then again, how exactly fitted to the parts of the body, in which they are placed, are the different kinds of joints, the ball and socket, the hinge, the sutures, etc.!

788. *Muscular Arrangement.—Their Mechanical Disadvantage, etc.—Contraction.*—Perhaps even more striking are the character, position, and mode of action of the muscles. Always in pairs, except where a single one is all that is needed; being antagonistic only where antagonism is wanted; being thick where great strength must be exerted, or some cavity must be filled to produce symmetry of form; being thin where wide surfaces were to be covered, or a proper proportion could not be secured between the different parts of the body. Then how wonderful that the great mechanical disadvantage, at which muscles act, which at first sight seems so obviously a defect

of arrangement, should on reflection be found wisely adapted to our wants and comfort. The mode in which the muscles act by mere contraction, is the simplest possible; yet when we inquire how this is effected, we find ourselves in contact with some of the profoundest and most difficult of all subjects: there is not only design, but unfathomable wisdom here.

789. *Harmony of Chemical and Vital Agencies.*—The conjoint operation of chemical and vital agencies in building up and perfecting the system, and freeing it from impurities, is another marked example of design. These agencies, the chemical especially, are blind, and we might expect that they would as often destroy as they would preserve. But though they are incessantly at work all over the system, as if it were a busy laboratory, in building up the tissues, in converting elements into immediate principles, and in separating and casting out of the body the superfluous and deleterious materials, all goes right till Providence permits disease or accident to disturb the harmony between vitality and chemistry, and from the disastrous effects of their morbid action, we learn how wisely ordered was their healthy operation.

790. *Special Arrangement exhibiting Design.*—There are some special contrivances and arrangements in the animal frame, which strikingly show design, because it looks as if the Author of Nature had made a modification of his plan to meet exigencies. Take a few examples.

791. *Looped Muscles.*—Look at the looped muscles. There the tendon is fastened by a loop, in order that the direction of the force, applied in contracting the muscle, may be more or less changed, made in some instances, as in the oblique muscle of the eye, to pull in an opposite direction; or at right angles, as when the digastric muscle draws down the chin.

792. *Anastomosis of Blood-Vessels.*—Then there is the inosculation of the blood-vessels. How obviously this is in-

tended as a security, when some of the blood-vessels are wounded and can not transmit the blood. It then seeks those side channels, and soon they so enlarge as to give free passage to all the blood that is needed, even though a large vessel has been closed. If man had constructed a machine with such an arrangement we should have been sure what was the design. Why doubt the same in respect to God's work?

793. *Protection of Large Vessels.*—Again, the large blood-vessels and nerves are placed deep in the system, and where they pass by prominent joints, grooves, or tubes, are made for them; or where one side of a joint is exposed to injury and the other comparatively secure, the important vessels are grouped together on the less exposed side, as in the groin and arm-pit.

794. *Annular Ligaments.*—Take, for another example, the annular ligaments around the wrist and ankle. Who can doubt that they were placed there to prevent the tendons of the muscles from starting out of their places, when the muscles are strongly contracted and the feet and hands bent? If so, who can doubt that a Being of infinite wisdom devised and executed this arrangement?

795. *Nervous Power.*—But all this wise disposition of the parts of the body might have been made and yet the whole have been useless, had not some vivifying force been added. Therefore the nervous system was contrived and incorporated with every part of the body, commencing with the brain and ramifying to all the extremities. It needed, too, a central power to direct and control the nervous energy, and therefore the mind, an immaterial and immortal principle, was enthroned in the brain. From thence, as along so many conducting wires, and doubtless by means of galvanic agency, it sends out its orders to originate and control every muscular movement and keep in play every function of the body. The nervous system, then, is the mysterious connecting link between mind and matter, and the admirable manner in which it performs its

functions and enables the thinking principle to manifest its astonishing powers, shows the nervous system to be the most wonderful of all the contrivances which Infinite Wisdom has placed in the human body. What could demand an Infinite Deity if such a contrivance did not?

796. Dependencies of one System upon Another.—The connection between mind and body, however, is only imperfectly understood, and therefore there is one other thing which exhibits more impressively than the nervous system and the mental powers the agency of an infinitely wise Being. The human body is made up of quite a number of minor systems of organizations apparently independent of one another, yet all in fact mutually dependent and combined into one complete and perfect system, with the parts all exactly adapted to one another. Could any thing less than Infinite Wisdom have accomplished so marvellous a work?

797. The same Plan Exhibited in the whole Animal Kingdom.—Yet if we extend our researches through the whole animal kingdom, we shall find that this same mutual adaptation and correlation extend through the whole series, so that all are but parts of a mighty whole. From man downwards through the hundreds of thousands of species, to the humblest animalcule, each occupies a fitting place, and every link of the long chain is in perfect harmony with all the rest, so that the skillful anatomist, knowing one part of the chain, can delineate the rest, just as a single bone of an animal often determines the character of its whole frame. What vast reaches of thought, what wonders of wisdom, what boundlessness of power must it have required, to weave together so vast and varied a system into one golden web of harmonies!

II. PROOFS OF DIVINE BENEVOLENCE

798. All Organs and Functions Normally Produce Happiness.—One proof of Divine benevolence is, that all the

organs and their functions are adapted to promote the welfare of the individual. They may incidentally result in evil; but the object was to produce happiness. One object of the nervous system was to guard us against injuries by putting us on our guard against them. But in case of injury or diseased action, intense suffering often results; and while enduring it we are apt to forget the grand object of the nerves of sensation, and imagine incidental to be intentional evil. So carnivorous teeth and poison fangs are intended to provide animals with food and the means of defense. But they may produce great incidental evils by being used as animals have the power to do, and are sometimes incited to do, aside from the normal objects for which they were given. Indeed there is no organ or operation whose leading object is not the production of happiness; and therefore we infer the predominant disposition of the Author of nature to be benevolent.

799. *Pleasure Superadded to Functions when not Required.*—A second fact leading to the same conclusion is, that often pleasure is superadded to animal functions, when it is unnecessary to their perfect performance. It was not necessary to perfect vision that the colors in nature should be agreeable; that the earth, for instance, should be green, or that colors in flowers should be harmoniously blended. It was not necessary for the support of the system that gustatory enjoyment should accompany the reception of food; for severe hunger would have been sufficient to impel us to eat, even though suffering followed. And so in a thousand other instances that might be named. On the other hand, no example can be found where unnecessary pain attends functional operations. The Author of such a system must be benevolent.

800. *More Modes than One Provided for the same Functions.*—A third evidence of benevolent design in the Author of the animal system is the provision often made of more than one mode for the performance of important functions. In the act of swallowing, for instance, the danger is great that par-

ticles of food may pass into the lungs. Hence not only is the epiglottis provided to close upon the glottis like a valve by the very movement that carries down the food ; but the glottis itself is endowed with such extreme sensibility that it instantly closes upon the approach of a foreign body. The inosculation of the blood-vessels has already been described, furnishing a double means of circulation as a resort when one fails. We might also refer to the two cerebral hemispheres, two lobes to the lungs, two eyes, two hands, and two feet, so that the loss of one does not obliterate the function. All this certainly looks like the benevolent provision of a kind parent.

801. *Surplus or Reserve Power.*—And so, in the fourth place, does the surplus power given to the organs for exigencies above what is necessary exhibit benevolence. In the muscles there seems to be no limit to this excess of force, save in the ability of the fibers to endure the strain. The digestive organs are capable of mastering a much larger amount of food than is necessary, and the secretory organs at times give out a much larger than the normal quantity of their peculiar products. If it were not so, life would be sacrificed in thousands of instances where now the use of the surplus power preserves it. If God is not benevolent how happens it that this special provision for exigencies should always promote the welfare of animals ?

802. *Vicarious Power.*—In the fifth place, the vicarious power given to some of the organs teaches the same lesson. When one or more of the senses is destroyed or defective, the others can often, in a good measure, supply their place : touch, for instance, the place of seeing and hearing. So, also, it is said when the glands appropriated to certain secretions are injured or destroyed, others whose normal secretion is quite different, can elaborate the principles ordinarily given out by the injured ones.

803. *Adaptation of Organs to Different Circumstances.*—The power of all the organs to adapt themselves to different

circumstances is a sixth example of benevolent intention in the Author of nature. The range of this power is limited; and yet we are often surprised to what widely different conditions we can be accustomed, and yet be comfortable in them by new habits. In such a changing world as this is, such a power seems almost indispensable, and yet only infinite skill could attach it to organs which are controlled by inflexible chemical and vital laws. Malevolence surely never would have bestowed it.

804. *Recuperative Power.*—The recuperative power of the animal system furnishes us with a seventh example of benevolent provision by the Creator. However deeply accident or disease may have affected the system, if the vital powers be not destroyed, it is possible frequently to bring it back again to a state as sound and vigorous as before. The records of pathology and surgery furnish most astonishing cases of such restorations. And since accident and disease are so common, that scarcely any adult can boast of immunity from them, what a sad picture would society present of cripples and invalids, were this recuperative power wanting. It would be just such a picture as infinite malevolence would delight in. Its opposite therefore indicates benevolence.

805. *Prospective Benevolence.*—One other example only will be given, and that may be called prospective benevolence. Wasps and some other insects have an instinct which leads them to deposit along with their eggs a supply of food for the young insects when they are hatched, sufficient to nourish them till they are old enough to take care of themselves. In other animals nature provides a supply of milk to be ready just at the time when needed by the progeny. The adult man needs a firmer set of teeth than the infant, and so the germs of these are placed beneath the earlier teeth, and these at the proper time push their way upward, and crowd the first set out of their sockets. In such cases the wants of animals were anticipated by their Creator, just as a be-

nevolent parent provides beforehand for the future needs and happiness of his children.

806.—III. ANATOMY AND PHYSIOLOGY FURNISH PRESUMPTIVE EVIDENCE THAT THE WORLD IS IN A FALLEN CONDITION.

807. Benevolence blended with Pain.—We have shown that benevolence decidedly predominates in all the organization and functions of the animal system. But it is not unmixed benevolence, as we shall now attempt to show. There are evils connected with our physical condition, such as we can not suppose would exist in a paradisaical state, and the inference is that these evils are best accounted for by the supposition that the world is adapted rather for a fallen than for a holy being. Let us look at some examples of evils which we can not suppose a Being of Infinite Benevolence and Power would connect with a state of perfect holiness.

808. The Nerves much more Sensitive than is necessary to Protect.—1. The nervous system produces suffering far beyond what is necessary, to put us on our guard against accidents and injurious agents. To awaken and cultivate such prudence in respect to these evils, seems obviously a leading object of pain and suffering: for the nerves are most abundant and sensitive at the surface of the body. But in many diseases the suffering is intense. Indeed, exasperated and maddened nerves produce the very climax of human anguish. But some other object besides awakening a salutary caution against evil must be in view by such suffering. Now we know, that as a matter of discipline for a depraved and sinful being, it is eminently salutary. It affords therefore a presumptive proof that such is man's character.

809. Impossibility of avoiding Accidents and Disease.—2. Man's exposure to accidents and diseases, which no human foresight can avoid, leads to the same conclusion.

810. That he is thus liable, we need not attempt to prove, because all will acknowledge it. But why should he be so exposed under the government of a Being of Infinite Benevolence, if there were not something in his character which demanded this severity of discipline? What can that be but an alienated, rebellious heart, which no milder means will subdue?

811. Evil incidental to every Function.—3. Evil is incidental to the functions of every organ in the body. Vision exposes us to be witnesses of many most unpleasant scenes and objects, hearing to sounds most grating, taste and smell to odors and solids disgusting and poisonous; locomotion makes us liable to fatigue and bodily injuries, and disease especially assails every organ. We can not conceive these incidental evils to be necessary in a world of perfect purity and happiness. But they are wisely adapted to a fallen being, and therefore the presumption is that man is in such a fallen state.

812.—Universality of Death.—4. The existence and universality of death lead to the same conclusion.

813. It may indeed be made probable that in such a state of things as the present, death is a blessing even to the inferior creatures. But it would not be so in an unfallen paradisaical state. It must be an immense drawback from the happiness of such a state. It is, however, a fit and probably an inevitable concomitant and consequence of sin. Where it is universal, therefore, the presumption is that it is a fallen state.

814. Condition of Man not without Bright Prospects.—5. But though anatomy and physiology present so many proofs of man's fallen condition, yet the evidence already adduced that benevolence vastly predominates, affords to the student of natural theology a strong presumption that it is not a hopeless condition. For if there was no such thing as recovery, why so many tokens of kindness? Why not give up the offender at once into the hands of justice, and let the work of retribution commence? How the recovery might be effected revelation alone could show.

Objection.—It is said that these arguments would prove the inferior animals, even those that lived long before man, to be in a fallen condition, since they both suffer and die.

Answer.—The lower animals, not having a moral nature, cannot sin; but they may suffer in consequence of their connection with sinful man. The world, from the beginning, was adapted to him as a fallen being, and of course all other animals must be subject, like him, to suffering and death. This sympathy of all nature with man's fallen condition is clearly taught in Revelation. (See Rom. viii., 18-23.)

815.—IV. ANATOMY AND PHYSIOLOGY FURNISH PROOF OF THE DIVINE UNITY.

That is, they show that only one Mind could have been concerned in the plan of animal organization.

816.—1. *The Conspiracy of all the Parts to Produce the Same End.*—This appears, in the first place, from the conspiracy of all the tissues and organs to produce a single result. There are as many as a million of parts in the human body, all of which must go right to keep the system in a healthy state. It may worry us when some of them go wrong, as in case of disease; but if many of them become deranged death ensues. An attentive observer of the race will see that all these parts are originally arranged so as to conspire in the production of health and happiness. There could have been no divided counsels in such a work.

817.—2. *Relations of Different Individuals in the Animal Kingdom.*—The relations of all the branches and even individuals of the whole animal kingdom to one another afford a still more striking evidence of divine unity. For here the objects to be compared are multiplied a thousand fold, and the extremes in organization, in habits, and modes of living are immeasurably wide. Yet there is such a relation among them all as to show them all belonging to one system, bound together in the closest harmony. All must, therefore, have been the work of one Infinite Mind. Or if more than one was concerned, each must have had the same plan; and the idea is absurd that there can exist more than one infinite mind.

818.—V. ANATOMY AND PHYSIOLOGY DISPROVE THE ATHEISTIC HYPOTHESIS THAT THE DEVELOPMENT OF ANIMAL ORGANS IS THE RESULT OF MERE LAW.

819. *The Development Hypothesis.*—This hypothesis supposes that the organs were not contrived and constructed by an intelligent mind for the uses to which they are applied, but that the wants of the living mass of almost amorphous matter led to such efforts as ultimately to form an organ. Thus the desire for food in a mass of vitalized jelly caused it to protrude certain points which ultimately became hands, and the desire of locomotion formed the feet and legs. To form the organs in this manner it would be necessary that the use of parts of the living unorganized mass or body should have a natural tendency to produce them. If then we can show that in some cases this tendency would be exactly the opposite, the hypothesis must fall. We need give only a few examples to show that such is the case. Take the looped muscles, such as those in the back of the eye. Any effort of matter behind the eye to move the ball must draw in a direct line, not in the round about course of a loop attached to the orbit. Take the case of the annular ligaments at the wrist and ankle. The conatus of the muscles to move the fingers and toes would tend to destroy but not to form such a ligament. They are as obviously intended as any thing can be to counteract the conatus of the tendons to fly off when the muscles contract.

820. Such facts so manifestly show the absurdity of the hypothesis under consideration, that examples need not be multiplied. It is true of nine tenths of the organs, that an effort of vitality to perform their functions before their existence would have a tendency the opposite of their formation.

821.—VI. ANATOMY AND PHYSIOLOGY SHOW THE UNREASONABLENESS OF OBJECTING TO MYSTERY IN RELIGION.

822. Any objection against religion that will lie with equal force against the constitution and course of nature is futile. For none but the atheist will deny that nature is the work of God, and it is not reasonable to object to that in religion which we allow to exist in nature. But the cases of mystery in anatomy and physiology are more striking than in religion. A few examples will suffice.

823.—1. Muscular movement. We can see that muscles contract, but the power that does it is concealed. We find that this power comes from the brain through the nerves; but this does not show us how the work is done. We find that electricity is concerned; but why should electricity contract a muscle more than a wire? This carries us to the end of our knowledge, and still we know nothing of the nature of that force by which the will is able to move a muscle. The whole range of science gives not the slightest clue to the mystery. It is, in fact, as profound as any in natural or revealed religion, and until we can solve this we have no right to object to any religious doctrine on the ground of mystery.

824.—2. The entire connection between mind and matter teaches the same lesson. When we have stated the facts as to their mutual influence, we have nearly reached the limit of our knowledge of the subject. There is no physical law or mental law either that can explain their action and reaction. All attempts to do this amount to little more than the vaguest hypothesis. Any thinking man who studies the phenomena will be impressed by the mystery that hangs over them, and if he be a true philosopher will be slow to reject any doctrine of religion because it has depths in it which he can not fathom.

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 Access'ory heart, 238.
Aerati'n, purifying by air.
Afferent, carrying to.
 After tastes, 409.
 Air, amount used in breathing, 253.
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Albu'men, a proximate principle, 12.
 Albu'minose, 12.
Alga, sea weeds.
Ambulatory, pertaining to a walk.
Amorphous, without shape.
 Amphiarthro'sis, 66.
 Anastomo'sis, 202.
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Anchylosed, grown together.
*Anfractuositie*s, depressions on the brain.
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Animalcules, minute animals.
An'nular, like a ring.
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Antiseptic, preventive of decay.
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A'pez, point or summit.
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 Appendages of cells, 18.
 A'queous humor, 374.
Aquiferous, water bearing.
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Articulate, to make a joint.
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Assimilation, conversion of matter into the substance of the body.
 Atmospheric pressure in joints, 71.
Audition, hearing.
 Au'ditory nerves, 329.
 Au'ricles, 201.
Automat'ic, acting apparently without the will.
 Ax'illary artery, 206.
 Azot'ic, containing nitrogen.
As'otised, containing nitrogen.

B.

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 Basement membrane, 17, 293.
Beaded, like a string of beads.
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C.

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Calcareous, hard like limestone.
Calcifed, made hard like limestone.
 Calcium in the body, 7.
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Calorific, heat producing.
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Carnivorous, flesh eating.
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 Cartilage, vertebral, 42.
Cartilaginous, made of cartilage.
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Cellular, having cells.
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 Clavicle, 57, 78, 96.
Clavica, a sac appended to the intestines.
Coagulable, capable of hardening.

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Conatus, attempt.
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Con'dyle, elevation or eminence on a bone.
Convoluted, rolled together like a tube.
Coördination, working or designing together.
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Coriaceous, like leather.
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Cor'neous, like horn.
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Cor'puscles, little bodies or cells.
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Cra'nium, skull.
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Crustaceans, animals like the crab and
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Cuta'neous, relating to the skin.
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Cytogen'esis, cell production.

D.

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 Death universal, 429.
Decussation, crossing like an X.
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Denti'tion, appearance of teeth.
Denizen, an inhabitant.
Dermatology, science of the skin.
Dermis, skin.
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Disassimilation, process of waste.
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Duplicative folding or doubling.
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Echinoderms, radiate animals.
Efferent, carrying away from.
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 Elementary tissue, 14.
Emaciation, wasting away.
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Epithelial, relating to the epithelium.
Epithelium, outer surface of mucous and other membrane.
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Excrementitious, waste or superfluous.
 Ex'osmose, 17.
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- F.
- Facet*, a little surface or face.
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Fu'siform, spindle shaped.

G.

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Ganglia, small knots or masses of nervous matter.
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Genus, a group of species.
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Gizzard, second stomach of fowls.
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Glob'ule, spherical particle of matter.
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Hepat'ic, pertaining to the liver.
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Herbiv'orous, vegetable eaters.
Hexagonal, with six sides.
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Histogenet'ic, tissue making.
Histol'ogy, 14.
Homoge'neous, of the same character throughout.
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In'bricated, overlapping like shingles on a roof.
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Interosseous, between the bones.
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Invertebrate, without internal skeleton.
 Iris, 371.
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L.

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Lacuna, spaces.
 " of bone, 33.
Lacunar, filled with lacunæ.
Lamellæ, thin layers or plates.
Laryngeal, relating to the Larynx.
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Marmot, a rodent or gnawing animal.
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Media, or humors.
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Medusæ, radiate animals.
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Metamor'phosis, change.
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Mimosa, plant of the order leguminosæ.
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Nitrogenous, containing nitrogen.

Normal, according to the standard.

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Ornithoryn'chus, an animal of the class mammalia.

Oscillatory, vibrating.

Ossicles, little bones.

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Otoliths, bony particles of the ear.

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Pedun'cle, a stalk or stem.

Pedun'culated, having a stalk or peduncle.

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Pen'niform, feather-shaped.

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Plasma, watery portion of the blood.

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Polyhe'dral, with many ends.

Polyps, radiate animals.

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" vicarious in organs, 426.

" recuperative in the system, 427.

Prehen'sile, adapted for seizing.

Prehen'sion, the act of grasping.

Primary tissue, 14, 22.

Principles, immediate, grouped, 8, 9.

Prismoid, like a prism.

Pristine, primary.

Process, an elevation on a bone.

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Psoas muscle, 126.

Pty'aline, 172.

Pu'bis, 61.

Pulsations of heart, 227.

Pyloric appendages, 194.

Pylo'rus, the lower orifice of the stomach.

Q.

Quadran'gular, with 4 angles.

Quadrilat'eral, " " sides.

R.

Ra'dial artery, 208.

Radia'ta, 85.

Radiata, skeleton of, 106.
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 Ra'dius, 59.
Ram'ify, to give off branches.
 Rectum, 162.
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 Retic'ulum, 186.
 Ret'ina, 372.
Retractile, capable of being drawn back.
 Ribs, 55, 96.
 Rickets, cause of, 82.
Ro'dent, gnawing.
 Rota'tion, 68.
Ru'minants, animals that chew the cud like the cow.

S.

Sac'ciform, like a sac.
 Sa'cral plexus, 334.
 Sa'crum, 41.
 Sali'va, 16, 172.
 Sal'ivary glands, 155.
 Salt in the human body, 11.
Sapona'ceous, soapy.
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Scle'rous, hard like bone.
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Seg'ments, divisions.
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Stell'ate, star-shaped.
Stem'mata, 387.
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Suppura'tion, forming of pus.
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Syn'chronous, at the same time.
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T.

Tac'tile, susceptible of touch.
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 Tegument^ary, relating to the skin.
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 Thoracic, pertaining to the chest.
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 Tissue, simple fibrous, 22.
 " white fibrous, 22.
 " yellow " 22.
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 Transverse, crosswise.
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U.

Ulceration, ulcer-forming.
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 " dorsal, 41, 85, 93.
 " lumbar, 41, 85.
 " sacral, 85.
 " caudal, 85, 93.
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 Vertebra^a, 85.
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 Vestibule, 391.
 Vibratile, susceptible of vibration.
 Villi, hair-like appendages.
 Viscera, contents of an animal cavity.
 Viscid, thick like syrup.
 Vision, limits of, 382.
 Vitalization, the act of giving life.
 Vitreous humor, 375.
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W.

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